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Grape Pests IN CALIFORNIA

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California vineyards . . .

are prey to more than 30 kinds of insect pests. Not all of these represent serious threats; not all of them occur in all grape-growing areas. But no region is free from attack; no region can disregard the danger of infestation by a pest from which it has been free; and pests that now do negligible damage may, if not kept in check, grow in importance

THIS CIRCULAR brings you a roundup of the insect pests of grapes in California. It tells how to identify them—both by their appearance and the damage they do—and prescribes the latest and most effective methods for their control.

NEW CHEMICALS are now available for the war on these insect enemies. Their effective use depends upon a knowledge of the insect's life cycle and habits. Their continued use depends upon the insect's ability to counterattack by developing resistance. New chemical weapons may have to be developed, but the life history of the insect will remain essentially unchanged. The more you know about these pests, therefore, the better equipped you will be to protect your vineyard against invasion and damage.

A SEASONAL CHART in the center of the circular tells in condensed form the symptoms of damage to watch for and the months when they are most apt to occur. All pests of economic importance are included.

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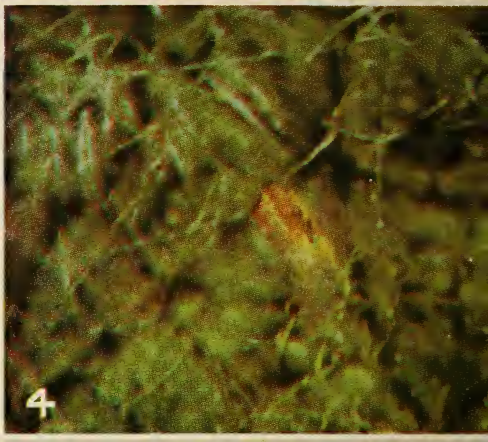
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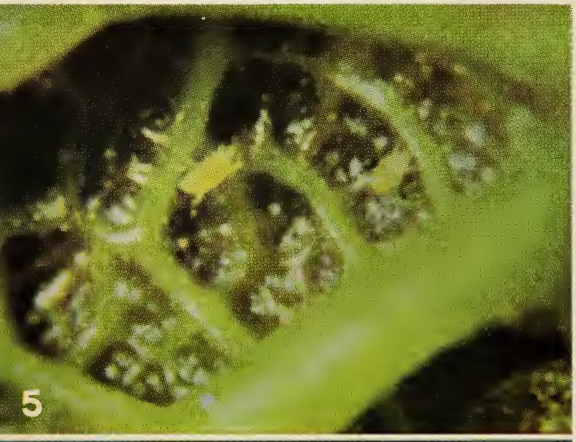
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Grape Pests IN CALIFORNIA

LESLIE M. SMITH • EUGENE M. STAFFORD

ALTHOUGH more than 30 types of pests attack grapes in California, only 14 are considered as frequently serious, while the others are regarded as minor pests. Those that occur most widely and are capable of the greatest damage are the grape leafhopper, Pacific mite, Willamette mite, phylloxera, grape leaf folder, nematodes, grape mealybug, cutworms, bud mite, grape bud beetle, grasshoppers, hoplia beetle, sphinx moths, and western grape skeletonizer.

Very few of the serious pests are found in all grape-growing areas of the state. Among the factors contributing to the spotty distribution of grape pests are variations in climate, soil, varieties, rootstocks, parasites, elevation, and isolation. For example, grape phylloxera is no problem on sandy soils, but unless grapes are grown on resistant rootstocks it may be serious on heavy soils, which are apt to crack. The grape leaf folder, a serious pest in the southern half of the San Joaquin Valley, is of little importance elsewhere.

This spotty distribution is further complicated by a spotty occurrence throughout the years. Many serious grape pests appear sporadically, do serious damage for one or two years, then subside to a minor position for an indefinite period. Many grape growers in the mid-San Joaquin Valley can well remember the outbreak of the grape sphinx moth that occurred in the late nineteen-twenties. Since that time there has been no great economic infestation of the grape sphinx.

The natural enemies of a pest are, to a great extent, responsible for this variation in pest abundance. These natural enemies are the unknown friends of the grape growers, and without their aid grape growing would be almost impossible. Some are parasites—smaller than the pest and frequently living inside the pest's body during its larval stage; others are predators—larger than the pest, living independently of it, and feeding externally on many individuals.

When a parasite reduces a pest population nearly to zero, it has so depleted its own food supply that it, too, nearly disappears. The few remaining individuals of the pest species may require

The color photos show: 1. grape leafhopper; 2. variegated leafhopper (both magnified about 12 times); 3. leaf showing typical leafhopper damage; 4. Pacific mite; 5. Willamette mite (both magnified about 28 times); 6. leaf series showing progressive mite damage, reading counterclockwise from normal leaf at lower right; 7. grape mealybug with cottony wax egg sac and orange eggs on a grape berry (about 4 times natural size); 8. grape phylloxera on a large grape root (about 8 times natural size).

several years to increase to damaging numbers. When the pest is abundant again, the few remaining parasites may require several years to increase to the point that they again nearly exterminate the pest. In this manner cyclic outbreaks occur. The grape mealybug is an example of a pest that fluctuates over a cycle of many years, declining or flourishing according to the abundance of its parasites.

In other cases parasites and predators control the occurrence of a pest within the year's cycle. For example, the many species of parasites and predators that feed on red spider mites reduce the mites nearly to extinction during March and April when the mites reproduce slowly. Sometimes, however, the beneficial forms fail to appear in the early spring, the red spider mites increase steadily through March and April, and a severe red spider mite year is the result. Even when this natural seasonal control takes place, however, red spider mites occur later on in sufficient numbers to require other means of control.

Present cultural practices in vineyards doubtless control insects that, under other conditions, could be serious pests.

Thus, early spring cultivation, turning under weeds or cover crops, reduces the breeding places of the grass thrips and helps prevent a build-up of thrips population. Similarly, pruning practices that remove almost all of the year's growth of new wood are responsible for the removal of a high percentage of scale insects that might otherwise build up in enormous numbers.

But in spite of the best cultural practices, some pests of grapes do severe damage. Rare indeed is the vineyard that can go for even one year without chemical treatment for one or more insect or mite pests. Insect damage varies from minor effects to complete loss of crop and in some instances the death of the vine. Typical crop-destroying insects are the bud mite, cutworms, and the grape bud beetle.

Leafhoppers and red spider mites may defoliate the vine before the fruit is ripe, and the berries remain so sour and low in sugar that the fruit is not marketable. When this occurs, the berries often raisin on the vine before ripening. Mealybugs may infest the bunches, making them too filthy for the market.

Repeated defoliation by any of the leaf-feeding pests weakens a vine until it is so unproductive that it should be removed before it falls prey to termites. Phylloxera feeding on the roots render the vine unproductive and will nearly kill it.

Before 1945 the grape grower had few chemicals with which to control these pests. His main weapons were sulfur, oil, lead arsenate, cryolite, and dinitro compounds. With the appearance of DDT in 1945 the grower gained a powerful new weapon that was especially effective

CAUTION!!!

Most insecticides are poisonous and should be handled with caution. Read all labels on insecticide packages or containers. If precautions are printed on these labels, follow them carefully. Avoid body contact with insecticides and do not inhale dust or fumes from them. Most liquid concentrates spilled on the skin or clothes are extremely dangerous. If this occurs, remove clothing immediately and bathe thoroughly with plenty of soap and water.

Parathion is highly toxic to human beings. Read instructions for use as printed on labels. A dust- and organic vapor-type respirator should be used to avoid inhaling the material.

against the grape leafhopper. Since then many new chemicals have appeared and been adapted to use on grapes. A number of new acaricides (mite-killers) have been developed, and many of these new compounds are now available to combat red spider mites on grapes.

The possibility that grape pests may acquire resistance to the chemicals recommended for their control is a constant threat to the success of our present methods. Some grape pests have already acquired resistance to a chemical that formerly controlled them. The Pacific mite is now almost totally resistant to sulfur dusts. Before 1922 it apparently was held in check by sulfur dust applied several times each spring for mildew control. In certain areas grape leafhoppers have become resistant to DDT. Other pests, such as the grape rootworm, now of minor importance because of effective insecticides, may reappear in serious numbers if they acquire resistance.

Insect injury to the crop can be considered from the standpoint of the current year only, or from the standpoint of the next several years. The current effect may be more damage to quality than a reduction in yield.

In general, pests such as hoplia and lighter infestations of bud mite, which reduce the current crop without otherwise harming the vine, increase the general vigor and vitality of the vine. On the other hand, pests that attack the leaves and cause defoliation while the vine tries to mature a normal crop place a severe strain on the vitality of the vine. The result is weaker, spindlier growth the following year. Quality, especially sugar content and appearance, is reduced with a reduction in vigor of the vine.

The primary objective of the grape grower is, of course, to produce a normal crop of good quality. The purpose of this circular is to aid the grower by providing the necessary information for intelligent use of the new chemicals.

The classification of pests according to the parts of the vine that are attacked is necessarily arbitrary, since some pests do not limit their attack to one part of the vine. Thrips, listed among pests that feed on the fruit, are also capable of causing severe damage to the leaves; the mealybug, another major fruit pest, lives mainly on the leaves. In the great majority of cases, however, the pests limit their attack to a single part of the vine.

The Leaves

GRAPE LEAFHOPPER

Almost every grape grower in the interior regions of California recognizes the typical light-colored mottling of the leaves that results from the feeding of the grape leafhopper, *Erythroneura elegantula* Osb. The grape leafhopper occurs in every major grape-growing area in California. A closely related species, the variegated leafhopper, *Erythroneura variabilis* Bea., damages grapes in southern California but is not found north of the Tehachapi Mountains.

Several periodic attacks of the grape leafhopper have caused great damage, particularly in the southern San Joaquin Valley. These attacks occurred in 1907–1908, 1913–1914, and 1929–1932.

Adverse weather conditions have been credited with sudden decreases in leafhopper populations, but it is not known exactly how this takes place. The grape leafhopper also has many natural enemies. Probably the most important is an egg parasite. Parasitized leafhopper eggs turn red, and great numbers of these red eggs may be seen in the late summers of certain years. Usually this parasite does not work in the first brood, but in certain years it has appeared early in the season.

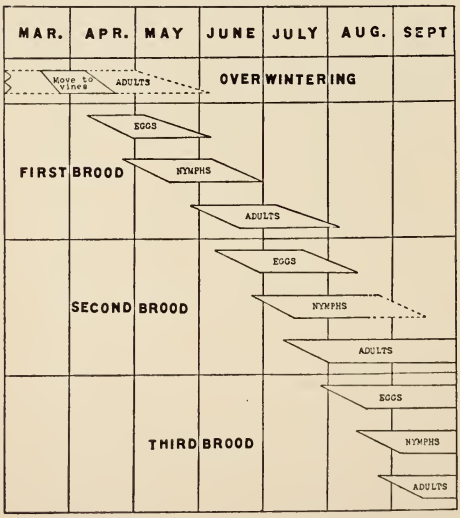


Diagram representing the life history of the grape leafhopper in relation to the time of appearance and length of the various stages of the three broods. Note that as the season advances, the overlapping of the broods becomes more complex. (After Lamiman.)

Appearance. Adult leafhoppers are narrow insects a little less than 1/8 inch long. The appearance and habits of the grape leafhopper and variegated leafhopper are very similar (see illustration, page 4). Adult grape leafhoppers are pale yellow with reddish and dark brown markings. On the overwintering adults the markings are a darker red than those of the spring and summer broods. Considerable variation occurs in the coloring and markings of each species. The variegated leafhopper usually has a darker general appearance, with larger areas of cloudy brown in the forewings than are found in the wings of the grape leafhopper. The dark brown spots on the wings and scutellum are usually smaller and more distinct on the grape leafhopper. Each forewing of the variegated leafhopper carries a spot of light yellow that usually does not appear on the forewings of the grape leafhopper.

Development. As soon as the vines leaf out in the spring the overwintered adults begin to move into the vineyards and feed on the developing leaves. Mating soon takes place and about two weeks after moving to the vines the females begin to lay eggs. Each female lays from 75 to 100 eggs over a period

Palomino grapes showing drops of leafhopper excrement blackened by sooty fungus.

of one or two months. The eggs are only about 3/100 inch long and are inserted singly into the leaf tissue just beneath the surface. They are difficult to see even with a hand lens. They appear as small bean-shaped blisters on the upper and lower surfaces of the leaf, the lower surface being somewhat more preferred. The tiny drops of sap found on the veins of young leaves should not be mistaken for eggs of the leafhopper or grape leaf folder or any other insect.

The eggs of the first brood hatch in 18 to 20 days depending on the temperature. The young leafhopper, or nymph, emerges through a slit in the egg and leaf. The first nymphal stage seems almost transparent and colorless except for the prominent red eyes. After feeding a while, the nymph molts to become a second-stage nymph. This process is repeated five times before the leafhopper becomes an adult. The later nymphal stages are very light green.

Since the nymphs tend to stay on the leaves where they hatch out, heavily infested leaves will show many whitish, shriveled cast skins. About 18 days are passed in completing the five nymphal stages. Each stage looks like the preceding one except that it is larger and the rudimentary wings are longer.

The nymphs feed almost entirely on the lower surface of the leaves. When disturbed, they often run with a crablike sideways movement. Mating takes place about two weeks after the adult stage is reached, and egg laying begins about one week later. The second brood of eggs takes only 8 to 12 weeks to hatch. Where the season is long enough there is a third generation each year.

In the Fresno area the first eggs may appear from April 7 to 15 depending on the weather. The first hatching may occur from April 24 to May 1, and the first summer adults appear from May 20 to 25. Comparable dates for the second brood of leafhoppers are: first eggs, June 5 to 10; first hatching, June 25 to 30; and first appearance of second-brood adults, July 1 to 8. For the third brood the dates are: July 25 to 30, August 10 to 15, and August 25 to 30. In the Coachella and Imperial valleys comparable development would be two to three weeks earlier. In the Lodi area the dates would be from 10 days to two weeks later than in Fresno.

On cold days in winter the adults are inactive, but one may find them under old leaves, in dead grass and straw along fences and ditches, in alfalfa, in old cotton fields, and in other similar places. On warm days they may be seen feeding on many different kinds of plants, including grasses and other weeds in and about the vineyards.

The overwintering adults have been found as far as one mile from the nearest grapes, but most of them spend the winter much nearer or actually in the vineyards. The number of adult leafhoppers that will be present in the spring depends on how many were present the preceding fall and the percentage that survive the winter. More leafhoppers die during winters in which there are long periods of cold, wet weather than in mild winters.

Injury. Throughout the entire growing season, from the time the vines leaf out in the spring up to leaf-fall, the leafhoppers feed exclusively on the vines.

Both nymphs and adults feed by sticking their mouthparts into the leaves and sucking out the contents. The removal of the green chlorophyll results in a pale spot around the point where the leafhopper has punctured the leaf. As the feeding punctures become more numerous, the pale areas grow larger and the leaf becomes characteristically mottled or variegated (see illustration, page 4). The whole leaf may turn pale, die and turn brown, and then fall. The older leaves in the crown of the vine are attacked first. If many leaves are so badly injured that they fall, the bunches may be sunburned. Lesser damage may cause deformed leaves, development of low sugar content in the berries, poorly maturing canes in the fall, and consequent weak growth of vines the following spring.

The sticky drops of leafhopper excrement catch dust particles and also support the growth of a black fungus. Such excreta on table grapes detract from their appearance and lower their value.

If uncontrolled, leafhoppers may be so numerous at harvest as to be a nuisance to the pickers. Swarms of leafhoppers may emerge from the vines when they are disturbed, flying into the eyes and nostrils of the pickers. In attempts to feed on the exposed skin of the pickers many leafhoppers will insert their mouthparts and cause additional discomfort.

Control. Grape leafhoppers may be controlled by three methods: spraying, dusting, and vapor-spraying. Sprays from ordinary hydraulic spray rigs using water as the diluent or dispersing agent may be used with excellent results. The disadvantages of spraying are: 1) it must be done before blossoming of table grapes to avoid marking the fruit; 2) it necessitates pulling heavy equipment through the vineyard; and 3) it is slow. On the other hand, a carefully applied spray will give excellent insect control.

In vapor-sprays the insecticide is dissolved in a light spray oil that is broken up into very fine droplets and carried to the vine by an air blast. The equipment is relatively light and moves through the vineyard rapidly. The application must be made before blossoming to avoid injury to the berries.

Vapor-sprays should not be applied too soon after sulfuring or injury will result from the sulfur-oil combination.

The application of oil and sulfur together is a well-known injurious combination for foliage and fruit. The application of oil to vines bearing a residue of sulfur or sulfur to vines bearing a residue of oil is also hazardous and may cause injury. At temperatures below 100° F it has generally been safe to apply oil spray two weeks after the last sulfur dusting or to apply sulfur one week after an oil spray. At higher temperatures and under very dry conditions these intervals may not be long enough. Local experience in each grape-growing region should form the best basis for judgment.

Dusting is by far the most widely used method of pest control by California grape growers. The equipment is light and application is rapid. Many different types of hand-operated and power-driven dusters are used in California. Thoroughness of dust coverage varies widely with the type of duster used and the amount of care taken in application.

Two insecticides—DDT and malathion—are used to control grape leafhoppers. DDT is widely used and has the advantage of long persistence, especially when combined with spray oils. Kills are not rapid so that results are most evident 5 to 7 days after application. With hydraulic sprayers enough of the DDT formulation should be used to apply 1 to 2 pounds of actual DDT per acre. The number of gallons of spray per acre will vary with the planting and amount of foliage present. Sprays of 5 per cent DDT in a very light oil at the rate of 1⅔ gallons per 100 gallons of water or 1½ pounds of 50 per cent DDT wettable powder plus 2 gallons of kerosene per 100 gallons of water have given very good results. Spray should be applied before bloom to avoid spotting the berries. For vapor-sprays 2.4 per cent DDT in oil should be used, applied at the rate of 4 to 5 gallons per acre. This treatment should not be used soon after sulfuring. Oil may also mark the berries after they have set.

Both 5 and 10 per cent DDT dusts are used in combination with sulfur. The amount of sulfur in the DDT dusts will depend on how much sulfur the grower wishes to apply per acre. This amount of sulfur, in turn, depends on the amount of foliage present and the temperature. DDT dusts should be used at the rate of 15 to 20 pounds per acre. Good dust coverage is an important factor in leafhopper control. Usually dusters traverse the vineyard through every other middle. Better results will be obtained if the duster traverses the vineyard through every middle between vine rows and so dusts each vine from two sides. Ten per cent DDT dust is used where leafhoppers are a serious problem year after year. To avoid excessive DDT residues on the berries, DDT should not be used too close to harvest. In very large vineyards cleanly cultivated in the winter, several rows around the border may be dusted early in the spring when the hoppers begin to move to the vines. At the same time, all the vegetation that can be reached by the duster from the borders of the vineyards is also dusted. This method of controlling the overwintered adults would not be effective for small vineyards or vineyards in which the leafhoppers could overwinter. Also the area outside the vineyard should not be pasture or in crops on which DDT would be hazardous or objectionable.

Malathion may be used for grape leafhopper control either as a spray or dust. It is effective in areas where leafhoppers have become resistant to DDT. Malathion and DDT are about equally safe for humans to handle. Malathion acts much more quickly in killing leafhoppers but is much less persistent than DDT. As a spray, malathion 25 per cent wettable powder should be used at the

rate of 1½ to 3 pounds per acre. An emulsifiable concentrate (4 pounds of malathion per gallon) is used at the rate of 1½ to 2 pints per acre. This spray should be used before bloom, at which time 200 to 300 gallons of spray per acre is required.

A dust containing sulfur and 4 per cent malathion should be used at the rate of 15 pounds per acre up to mid-April (Fresno area) to kill overwintered adults in the vineyard before they have laid eggs. As the amount of foliage increases, the dosage should be increased to 20 pounds per acre. One treatment may be enough up to the time the first-brood adults begin to lay eggs, provided temperatures are high enough. Cool weather decreases the effectiveness of malathion dust. This decrease in effectiveness may be noticed when the nighttime temperatures go below 50° F; it is particularly noticeable when daytime temperatures fall below 60° F. In such an event retreatment may be necessary.

After this time (early June in the Fresno area) two applications of 4 per cent malathion dust must be used about two weeks apart. This is necessary, since at the higher temperatures of the later season malathion does not persist long enough to kill nymphs hatching a week or so after treatment. The use of malathion is permitted up to two weeks before harvest. The most favorable time to treat with malathion is late May or early June after all eggs have hatched but before the newly matured adults have laid eggs.

PACIFIC MITE

Two kinds of red spider mites—the Pacific mite and the Willamette—do serious damage to vines in California. The more destructive of the two is the Pacific mite, *Tetranychus pacificus* McG. It is difficult or impossible to distinguish between these two pests because, even when fully grown, they are just barely visible to the unaided eye. A magnifying glass of at least ten power is therefore essential to see them.

Appearance. The Pacific mite can be recognized by its amber body and the two, four, or six large black spots on its back. The Willamette mite, on the other hand, is usually pale yellow with a row of minute, inconspicuous black dots along each side of the body (see illustration, page 4). Occasionally an infestation of both species is found wherein the adults are intermediate in color and spotting, and a hand magnifier will not suffice for a positive identification. In such cases, specimens must be submitted to a specialist for microscopic identification.

Development. During the winter the Pacific mites hibernate under the shaggy bark of the trunk and arms of the vine. They crawl into cracks and crevices in the bark during the summer, penetrating as deeply as possible, and usually almost reach the living cambium layer of the vine. Here they wedge their bodies into the smallest possible niches or cells in the bark. They often squeeze their bodies into such small spaces that they lose their typical oval form and become misshapen to fit the crevices. Their body color becomes orange and no trace of black spots remains. They are then in a true state of hibernation and totally motionless. If placed in the warm sun during the winter, they gradually become able to move about, but this warming-up process requires several hours.

They prefer to hibernate in the ripples in the bark on the underside of an arm where it joins the trunk. Growers can inspect their vineyards for Pacific mites during the winter by stripping the bark from such places and looking for the bright orange bodies. Here, again, a magnifying glass is most useful. If more than a dozen mites are found under a single arm, a serious mite infestation may follow next season. Failure to find

the mites in the winter does not indicate that the vineyard will be free from mite damage the following season, since a few individuals, too sparse to be found, may give rise to a damaging population.

With warm spring weather the mites leave the bark and move out to the opening buds about the time the first leaf opens from the bud. Here they establish themselves on the lower leaf surface and assemble in small groups, forming incipient colonies. Feeding starts immediately, the orange color fades to amber, and in a day or two the typical large black spots reappear on their bodies.

Only adult females go into hibernation and survive the winter, so in the spring all overwintered mites are egg layers. Egg laying starts within a few days after emergence from hibernation.

Development from newly laid eggs to the adult is slow during the cool spring days and may require a month or even six weeks to complete a generation. At this time the mite population is vulnerable to predators. Various kinds of beneficial insects and predatory mites feed on Pacific mites and may reduce them nearly to extinction in some vineyards.

Later in the spring, under the influence of warmer and longer days, the rate of growth and egg laying is speeded up. At midsummer the incubation period of the egg is only a day and a half. The newly hatched mite feeds for a day and a half, then becomes motionless while shedding its skin. This molting process likewise requires a day and a half. As soon as the skin is shed the mite resumes active feeding for another day and a half, then molts in the same length of time; this process is repeated for a total of three molts. After the third and last, the mite is a mature adult. It lives for approximately 30 days and may lay as many as five eggs a day.

The first mites enter hibernation in June, but this is unusual and occurs only on those vines that have been severely defoliated. Throughout July, August, and September more and more adult females wander down on the arms and trunk to hibernate under the bark. This movement is apparently the result of reduced food supply caused by severe mite injury to the vine.

During September and October the shorter, cooler days slow the mite's rate of reproduction. At this time the predatory mite, *Typhlodromus* sp., has reached a high population density in most California vineyards. These beneficial mites catch and kill the laggard Pacific mites that have been slow to seek hibernation quarters, and as a a result the leaves of the vines are usually stripped of Pacific mites in the early fall.

Injury. The first signs of Pacific mite injury are yellow spots on the upper surface of the leaves, indicative of a mite colony feeding on the lower surface. These are usually as large as a dime when first noticed and may begin to appear in April and May. However, the good work of the beneficial predators may have eliminated practically all members of the colony. Growers should examine the lower surface of the yellow spots with a magnifying glass to see if this has occurred before concluding that the time for chemical control has arrived.

With the advent of warm days the damage spreads rapidly from a yellow spot to cover the entire leaf (see illustration, page 4). Mites then crawl along the cane to adjacent leaves. Thus, at one stage of the development of injury it is usual to find one or more severely injured canes per vine while the rest of the vine remains green.

Hot weather causes a rapid development of mite damage that often catches the grower napping. Ten days may suffice for a green, healthy vineyard to change to a sickly brown, with vines severely injured.

On white grape varieties, such as Thompson Seedless, the yellowed leaves

turn light brown as the injury advances and finally the dead brown areas dry out. On black varieties, such as Zinfandel, the yellow areas soon turn red, then purplish-red, and the leaf tissue dies. As the dead leaf tissue dries out, it turns brown. The experienced grower can distinguish the dark, purplish-red color caused by the Pacific mite from the pinkish-red color produced by the grape leafhopper.

Control. Control of the Pacific mite has been in a state of constant evolution for many years. Before 1922 the Pacific mite was apparently controlled by sulfur dust applied for mildew. At about this time the mites developed a resistance to sulfur, particularly in the Manteca-Escalon area. By migration from this area, or by independent development of resistance in other parts of California, sulfur-resistant strains now occur in all vineyards north of the Tehachapis.

Various control methods used for about the next 20 years had serious weaknesses until the ethyl phosphate compounds appeared. The first of these compounds was TEPP (tetraethyl pyrophosphate). This material, used as a spray at one pint per 100 gallons of water, gives an excellent kill of all mobile stages of mites but fails to kill the eggs and the molting, or quiescent, forms. Since the mites are quiescent during half of their development, repeated applications of TEPP are required to reduce the mite population to a noninjurious level.

The next ethyl phosphate compound to appear was parathion. This material, applied as a spray at 2 pounds of wettable powder per 100 gallons of water, has killed all stages of the mites and yielded a good control in a single application. The mites in certain areas, however, appear to have developed resistance to parathion.

Another phosphate compound that has proved of value for the control of the Pacific mite is EPN-300. This material, at 1 pound of wettable powder (27 per cent active) per 100 gallons of water, kills all stages of the mites. *TEPP, parathion and EPN are highly toxic to man and must be handled with caution.*

In recent years several new acaricides have become available, which are relatively nontoxic to man and can be handled with ordinary caution. Some of these that have been found useful to control the Pacific mite on grapes are:

Trade Name	*Use per 100 gallons of water*
Dimite	2 pints of 25 per cent emulsion or 1 pound of 40 per cent wettable powder.
Aramite	1½ pounds of 15 per cent wettable powder.
Ovotran	2 pounds of 50 per cent wettable powder.

These materials should be applied when four or five leaves per vine, on the average, show yellow spots about as large as a dime. On medium-sized vines 600 gallons of mixed spray per acre should be used. The vines and especially the lower leaf surfaces where the mites live must be thoroughly wetted with the spray. A pressure of 400 pounds per square inch is required to turn and twist the leaves so as to expose the lower surfaces to the spray. Results will be proportional to the thoroughness of the application. Poor coverage will give disappointing results regardless of the material used. None of these materials should be applied within 30 days of picking. Wettable powders may leave a visible white deposit on the fruit at harvest if applied after the berries have started to color.

Ovotran is chiefly effective against the eggs of the mite and less effective against the adults. Consequently, this material should be used only against light infestations. Heavy infestations are reduced slowly by this material and considerable damage may occur after spraying.

Dusts and aerosols prepared from the above materials have given a fair control, but the results are decidedly inferior to full-coverage sprays. Repeated applications of dusts and aerosols in a single season are usually necessary to insure adequate protection.

WILLAMETTE MITE

The Willamette mite, *Tetranychus flavus* Ewing, is a serious pest of grapes in the Fresno area and farther south in the San Joaquin Valley. It occurs commonly in vineyards throughout the state but does little damage north of Fresno. This mite is apparently killed by sulfur (applied for mildew) in the northern part of the state, but has acquired resistance to sulfur in the southern San Joaquin Valley.

Appearance. To recognize this pest see the discussion under Pacific mite, p. 12.

Development. The life history, seasonal history, and habits of the Willamette mite are the same as those of the Pacific mite with a few important exceptions. One is that the Willamette mite occasionally overwinters in enormous numbers and emerges explosively in the spring when the buds are swollen but before the first leaf has unfolded.

These occasional early spring outbreaks are due to the Willamette mite's ability to escape a beneficial predatory mite, *Typhlodromus* sp. As long as sulfur is present on the vines for mildew control, the Willamette mite (north of Fresno) is kept at a low ebb. In the late summer as the sulfur is dissipated from the vines, the Willamette mite population increases. At this season the predatory mite takes a heavy toll of the Pacific mites, but it is unable to feed to any extent on the Willamette mite, which is very agile and can outrun its natural enemy. Mixed populations of mites have been observed on a single leaf, and it was noted that the predator reduced the Pacific mite population nearly to extinction, while the Willamette mite population markedly increased.

This survival makes it possible for a large population of Willamette mites to go into hibernation under the bark. They are occasionally found there in the winter in solid masses resembling a coating of yellow paint. As many as 500 mites may be found on a single square inch of bark. No such hibernating masses of Pacific mites have ever been found, and this accounts for the fact that the Pacific mite is not capable of early spring damage comparable to that of the Willamette mite.

Injury. Upon their emergence from hibernation the mites cluster on the swollen buds and feed extensively on the first small leaflet that unfolds. Under this attack the leaf turns black and dies, sometimes before it reaches an inch in diameter. The mites then move up to the next leaf, which suffers a similar fate, and so on until 8 or 10 leaves have been killed on each shoot. Sulfur dust is usually applied at this time, reducing the mites and preventing further damage.

The sulfur-resistant strain of the Willamette mite in the lower San Joaquin Valley feeds on the undersides of the leaves throughout the summer and produces a typical bronze-brown color on the upper sides of the leaves.

Control. In vineyards north of Fresno control of the Willamette mite is simply achieved with sulfur dust. In case the mites have overwintered in unusual numbers and the new leaves are turned black in the early spring, the sulfur should be applied immediately. Otherwise, normal sulfuring for mildew takes care of this pest.

In vineyards where the sulfur-resistant strain of the Willamette mite occurs, the control measures should be those given for the Pacific mite.

GRAPE LEAF FOLDER

For some grape growers in certain years, the leaf folder, *Desmia funeralis* (Hbn.), is the most serious pest. The moths fly about on the approach of darkness and continue to fly all during the night if the temperature is high enough. Just before harvest, the larvae of the grape leaf folder may ruin fancy table grapes by lowering quality below market standards.

Appearance. The adult grape leaf folder is a very dark brown, almost black, moth with a wing expanse of about 1 inch. The forewings in both sexes have two white spots. The hind wings of the female also have two white spots, while those of the male have only one large white spot. There are two white bands across the abdomen. The male antennae are thickened or knotted in the center; the female antennae are smooth.

Development. Three periods of flight occur each year in California, indicating three broods. The first moths of the season emerge from pupae that have overwintered. Moths occur from early May until the last week of May in the Fresno region. During this period the small, flat, iridescent, elliptical-shaped eggs (about 1/32 inch long) are laid on the leaves in places that are protected from the wind. Vines sheltered by any type of windbreak are preferred for egg laying. Thus, leaves from vines with good foliage, especially mature, sheltered leaves, show more eggs than do the leaves of weakly growing vines. Eggs are also laid on water sprouts or "suckers." It is in these sheltered places that the moths rest during the day.

Eggs are laid singly on the leaves, often in the angles between a vein and

Top, adult moth (female) of the grape leaf folder. Center, larva of leaf folder—black spots are excrement. Bottom, overwintering grape leaf folder.

the leaf surface. Smoother surfaces are preferred for egg laying. The eggs that are laid in the spring hatch in 10 to 17 days depending on the temperature. At first, the young worms, or larvae, feed in groups between leaves that they have webbed together. This first feeding is of a skeletonizing type. After about two weeks the larvae feed singly in the pencil-sized leaf rolls they make. These rolls are made by spinning strands of silk from the edge of the leaf to points nearer the center. As the silk strands dry, they contract and bend the edge of the leaf. Other strands are then made that curl the edge of the leaf into a roll. The upper leaf surface almost always forms the outside of the roll.

The larvae feed on the free edge of the leaf inside the rolls. Before becoming full-grown each larva makes two or more rolls, the newer ones being made farther out on the canes. The larvae have a pale yellowish-green, translucent appearance. As soon as feeding starts, the ingested leaf tissue gives them a bright green color. The larvae molt five times. When they show a distinct spot near the posterior end of the body, they are in their last stage, the one in which most of the feeding is done. When disturbed, the larvae wriggle vigorously and fall to the ground.

Work of the grape leaf folder. Note the silk strands used to form the roll. Feeding holes of young larvae can be seen in the lower part of the leaf.

After reaching full growth, the larva makes a small leaf fold or envelope at

Table 1. Average moth flight periods and time required for completion of various developmental stages of the grape leaf folder at Fresno, California.

Brood	Moth flight period	Time required for eggs to hatch	Total time in larval stages	Total time in pupal stage	Time required from egg to emergence of moth
First	April 2 to May 24	10 to 17 days	3 to 4 weeks	10 days to 2 weeks	6½ to 7½ weeks
Second	June 15 to July 15	4 to 5 days	2 to 3 weeks	7 to 11 days	4 to 5 weeks
Third	Aug. 3 to Sept. 5	4 to 5 days	3 to 5 weeks	overwinter	

the edge of the leaf. This tightly webbed leaf fold is partially cut away from the leaf. Inside this leaf fold the larva changes into a pupa, the intermediate stage between larva and moth. Moths emerge from the pupae and lay their eggs, thus starting another brood. The moths emerging in the summer lay almost all of their eggs on previously infested rolled leaves. This tends to concentrate the infestation on vines where the eggs were laid in the spring. Data concerning the development of the three broods at Fresno are given in table 1. When the dried leaves fall to the ground or soon after, the pupal envelope of the third brood breaks away from the leaves and it passes the winter among dead leaves and other debris. Some third-brood larvae may pupate in the loose bark on the trunks of the the vines.

Injury. The rolls made by the larvae reduce leaf area, thus restricting the leaf in its function of making food for the vines. In severe infestations the resulting defoliation may expose the berries to sunburn. The third-brood larvae in heavy infestations may feed in the bunches, breaking the skins of the berries and thus permitting the entrance of spoilage organisms.

Fortunately, several parasites tend to keep the grape leaf folder from becoming a major, more widespread, and annually recurring pest. These parasites usually increase during the summer and reduce the size of the third brood of leaf folders to such small numbers that little injury is done. Insect predators and birds also help reduce the leaf folder population. The years when the parasites failed were years of severe damage to grapes. Some observations indicated that grape leaf folders increased faster in vineyards where chemicals were applied for leafhopper control after mid-July. Apparently the insecticides used for leafhopper control also kill the parasites of the grape leaf folder but have little effect on the leaf folders themselves.

Control. Control by chemicals is best accomplished by treatments directed against the first-brood larvae. A persistent insecticide should be applied in the spring before the larvae can protect themselves in leaf rolls. If it is applied too soon, however, the vine will produce new growth that will be available for egg laying. Generally, the period when treatment is effective (Fresno region) is during the first three weeks of May, with the preferred time about mid-May.

There are two effective treatments: 1) a spray of 4 pounds of standard lead arsenate per 100 gallons of water; 2) a 50 per cent cryolite-sulfur dust at 20 pounds per acre. The lead arsenate spray is effective and more persistent than the dust and should be used when treatment is applied early. Another reason for applying lead arsenate early is that it will tend to leave a smaller residue on the framework of the bunches at harvest than a spray applied later in the spring. A less effective control is the use of 50 per cent cryolite-sulfur dust at 20 to 25 pounds per acre applied in early July to control worms of the second brood. Lead arsenate should not be used after the berries have formed.

Sometimes growers fail to obtain control with cryolite dust, especially in the second and third broods. In such cases a 2 per cent parathion dust at 20 pounds per acre has given good results. Parathion dust must be applied at least 21 days before harvest. Dusts applied for control of the second and third broods are generally directed to cover the upper and outer portions of the vines.

The practices of suckering and leaf-

CONTROL CHART

The center section of this circular is a removable control chart for the more common pests attacking grapes.

thinning remove many of the eggs of the grape leaf folder and are thus of some benefit in reducing the infestation.

WESTERN GRAPE SKELETONIZER

The caterpillars of the western grape skeletonizer, *Harrisina brillians* B. and McD., are gregarious, living in close groups on the lower surfaces of the grape leaves.

This pest was first found in California in 1941. Its native home is probably Mexico. Two years after its discovery in California it destroyed as much as 90 per cent of the crop in some vineyards in San Diego County. The first generation of moths, which emerge in May and June, can produce enough worms to defoliate a vineyard by early July.

Appearance. The caterpillar of the western grape skeletonizer is brilliantly colored, as indicated by its scientific name, *brillians*. The body is yellow with two prominent, purplish transverse bands and several narrow black ones. Each body segment has four tufts of long black spines. These spines are poisonous and when they come in contact with human skin will raise welts similar to those produced by nettles. When the caterpillars are full-grown and ready to transform to the adult moth, they are about ½ inch long.

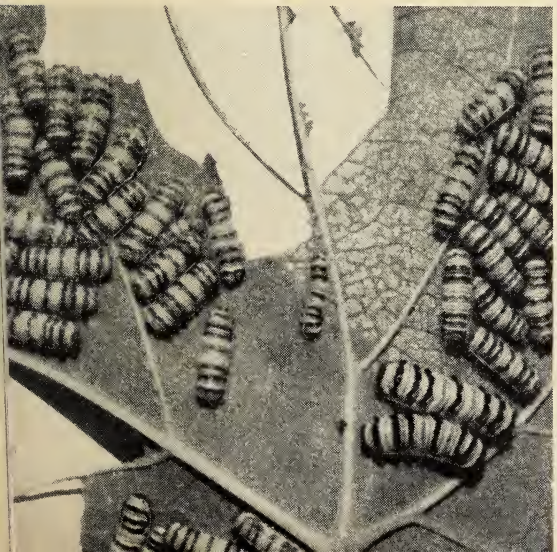
The adult moth has long, narrow wings, which it folds over its back when at rest. Their color varies from dark metallic bluish-black to greenish-black. When the wings are spread they measure 1 inch from tip to tip.

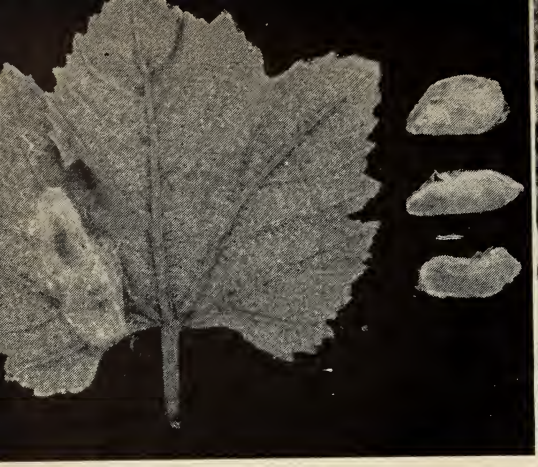
Development. When the caterpillar is fully grown, it spins a silken cocoon in which to pupate. The cocoons are irregular, dirty-white capsules and may be found in the trash around the base of the vine or under loose bark. If the cocoon is carefully opened, the light reddish-brown pupa may be removed intact. It can move the end of its body around in a circular motion.

After emerging from the cocoon, the adult moths mate, and the female lays her yellow, capsule-shaped eggs on the lower leaf surfaces, in groups of about 100. Such a patch of eggs is about as large as a five-cent piece. There are three generations a year.

Injury. During their progress across a leaf, the caterpillars of the grape skeletonizer eat the lower epidermis and green part of the leaf, leaving the upper epidermis intact like a window. As they become larger they disperse over the vine

Left, larvae of the western grape skeletonizer (life size). The leaf is eaten completely between the main veins. (Courtesy San Diego County Department of Agriculture.) Right, adult moth of the western grape skeletonizer (about twice natural size). (Photograph by W. H. Lange.)





Silken cocoons of the western grape skeletonizer. (Photograph by W. H. Lange.)

Eggs of the western grape skeletonizer on a grape leaf. (Photograph by W. H. Lange.)

and eat the upper epidermis also, thus making large holes that span between the larger veins of the leaf.

Control. Soon after the discovery of this pest in San Diego County, the California State Department of Agriculture inaugurated quarantine and suppressive measures. These measures have been very difficult to carry out because the skeletonizer lives on wild grapevines, which are located in almost inaccessible canyons. Nevertheless, the state has attempted to maintain a host-free band around the known infestations by cutting and killing wild grapevines with 2,4-D. Commercial vineyards within the infested area have been dusted twice each season with 45 per cent sodium fluoaluminate (Cryolite-50) at 25 to 50 pounds per acre, or with DDT dust. Thus far the pest has been confined to San Diego County and one section of Riverside County.

Galls formed by the erineum mite. This picture shows the upper and lower surfaces of two leaves. Note the swellings on the upper surface of the leaf and felty masses of hairs on the corresponding concave lower surface.

ERINEUM MITE

The work of the erineum mite, *Eriophyes vitis* (Pgst.), is first noticed in early spring. At this time the infested young leaves show bright pinkish or reddish swellings or galls on the upper surfaces. That portion of the leaf beneath the gall is concave on the underside and densely lined with a felty mass of curled plant hairs. These felty patches are called erinea.

Appearance. The erineum mite can be seen only under magnification. Its body is elongated, with short legs attached near the anterior end.

Development. The mites live and reproduce among the masses of abnormal leaf hairs that the plant produces in response to their feeding. If uncontrolled, they may increase enormously in these erinea. Some of the mites move to younger leaves on the vine and establish new erinea and new colonies.

Leaves less than ½ inch in diameter are apparently best suited for this purpose. Mites do not produce erinea on larger leaves. From the middle of August to leaf drop, the adult mites migrate to the axils of the leaves and crawl in under the bud scales. The migration occurs only at night. The winter is passed in the buds. In the spring the mites move to the new leaves to start their seasonal cycle over again.

Injury. In heavy infestations the entire lower surface of the leaf may be covered with erineum. In even more severe cases the upper surfaces of the leaves and even the tendrils may show this abnormal growth of plant hairs. In a short time the swellings on the upper sides of the leaves turn to the normal color of the leaf. Later in the season the erineum turns yellow, then, in August, brown.

Though the erineum mite often causes the grape grower some concern in the spring, very little damage from this pest has occurred in vineyards. The mite is generally distributed throughout California and has been taken from almost every cultivated variety of grape.

Control. Control is easily accomplished with sulfur dust as used for grape mildew control. In fact, the most severe cases of erineum have developed on vines that had received no sulfur dusting. Galled leaves do not become normal as a result of sulfur treatment because the dust only kills the mites and prevents further erineum production. There is some indication that the erineum mite may be developing resistance to sulfur in a few vineyards.

FALSE CHINCH BUG

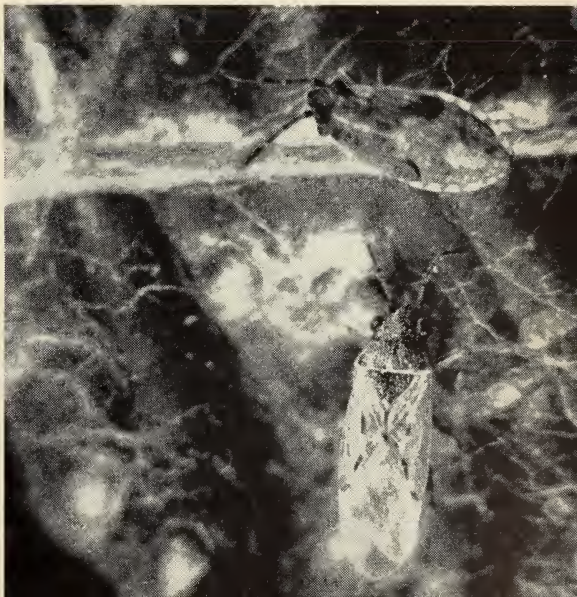
False chinch bugs, *Nysius ericae* (Schill.) breed in countless millions in grassland and pastures in the early spring. When the grass dries up, the bugs migrate in search of green food. A vineyard situated in their path may suffer serious injury. When they are forced to leave the grassland, they are mainly in the wingless, young stage and consequently migrate by walking. A number of winged adults are present, too, but instead of flying they march along with the wingless, immature ones.

Appearance. The adults are about ⅛ inch long and are light or dark gray. The young are gray with a reddish-brown abdomen.

Development. The eggs are laid at random on rubble in the soil or in cracks in the ground. All stages may hibernate, but the great majority pass the winter in the immature stage.

There are about six generations each year, and population pressure, which exhausts the food supply in the fall, may produce fall migrations.

Injury. When a horde of false chinch bugs invades a vineyard, they swarm up the trunks of the vines to the leaves



False chinch bug on the lower surface of a grape leaf. Above, immature bug; below, adult with wings.

where they immediately begin to suck the juices. Within three hours a healthy, vigorous vine may be completely wilted. Such leaves then turn brown, become dry, and fall off. Vines may be completely defoliated.

The most serious and destructive migrations occur in May and June as the grass dries up, but there are occasional migrations in the fall, during September and October.

Control. Control of this pest may be achieved by burning off the grassland from which the bugs are migrating when this is feasible. Usually burning is not feasible and chemical control must be used.

Since the bugs migrate mainly in one direction and the wilted vines along the edge of the vineyard clearly show the line along which they are entering the vineyard, it is possible to lay down a chemical barrier across the line of march and prevent further movement into the vineyard.

A band of chlordane or benzene hexachloride dust about 30 feet wide may be used for this purpose. Chlordane dust should contain 5 per cent active ingredient, whereas the benzene hexachloride dust should contain 1 per cent gamma isomer. The land should be dusted until the ground appears white, usually at the rate of about 100 pounds per acre. These dusts should be applied to the soil just outside the spread of the border row of vines, as along a lane or fence row.

If large numbers of the bugs enter the vineyard before the barrier strip is laid down, the infested border rows should be dusted with a 1 per cent lindane dust.

GRAPE RUST MITE

The feeding of the grape rust mite, *Calepitremeris vitis* (Can.), on the surface of the leaves causes a yellowing of the white grape varieties, which closely resembles the appearance of leaves that are slightly injured by the Pacific mite. On dark grapes the injured leaves become a brilliant red.

These light amber mites are microscopic in size. Under a 14-power hand lens they appear wormlike. They are broader at the front end and move about slowly.

These mites overwinter in the grape buds and begin egg laying in the spring. The emerging young infest the leaves and multiply on the leaves during the growing season. They may be found on both upper and lower surfaces. On the upper surface they tend to cluster along the main veins on green tissue.

If unchecked, the mites would attain such enormous numbers as to cause serious defoliation. Fortunately, they are easy prey to their many natural enemies, and control is rarely necessary. Sulfur dust applications used for mildew control also help keep the grape rust mite from becoming a destructive pest.

ACHEMON SPHINX MOTH

The achemon sphinx moth, *Pholus achemon* (Drury), is rarely seen because it flies at night and hides during the day. It feeds on the nectar of flowers, especially petunias.

Appearance. The moth is about as large as a hummingbird and hovers in the air outside a flower while feeding.

The caterpillars of the achemon sphinx, when they first hatch, are about 3/16 inch long. On the rear end they have a large black horn that is longer than the body. When they have grown to about ½ inch in length, they take on various colors. Some remain green, like the young worms, but others become pink, tan, or brick red (see cover illustration). At this time they lose the horn, and only a dark button remains in its place. They have a diagonal white stripe on their sides above each leg. When fully grown, the caterpillars are about 4 inches long and resemble their close relative, the well-known green tomato worm.

Development. The achemon sphinx lays large green eggs singly on the upper surfaces of the outer grape leaves. The eggs hatch 6 to 9 days after they are laid. At higher temperatures the incubation period is shorter. Immediately after hatching, the caterpillar eats a smooth round hole in the leaf and crawls through to the lower leaf surface, where it continues to eat small round holes in the leaf.

The caterpillars feed on the grape leaves for about 25 days. They then make their way to the ground, penetrate to a depth of 2 to 6 inches, construct a smooth-walled cell, and enter the pupal stage. The pupa is a spindle-shaped, mahogany-brown object about 2 inches long. If any number of these are plowed up during spring cultivation, the grower should be alerted for an outbreak of worms the following summer.

This pest overwinters in the pupal stage in the soil. The moths emerge from the soil during the first half of May. The second brood of moths appears in the vineyards during early July. The second brood of worms is much more numerous than the first, and their greatest damage is done during August. A generation is completed in about 55 days, and some years there is a small third generation.

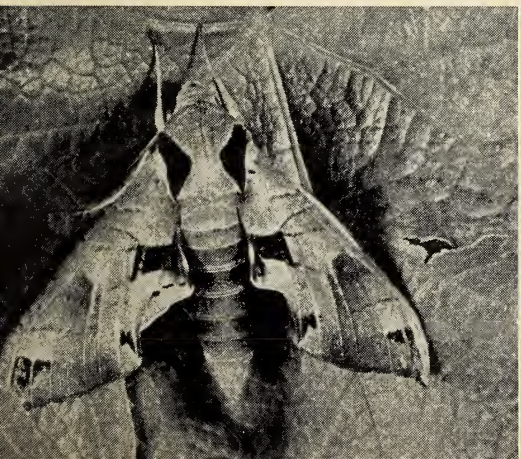
Injury. This pest is cyclic in appearance—that is, several years of severe damage are followed by several years of negligible injury. The most recent outbreak centered about 1927, and the outbreak previous to that ranged from 1919 to 1924. At that time a maximum of 500 worms was found on a single vine.

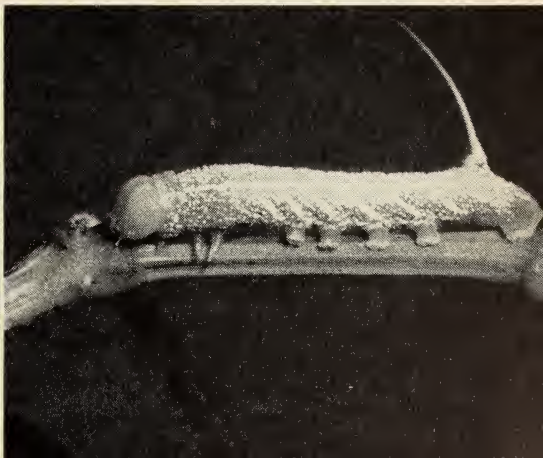
A large worm eats nine mature grape leaves every 24 hours. When a vine has been completely defoliated, the worms leave it and may walk a considerable distance to the nearest vine that still supports green leaves.

Control. Control of this pest with chemicals has not been necessary since the adoption of DDT for the control of the grape leafhopper. The DDT seems to have been holding the achemon sphinx in check. Outbreaks might, therefore, be expected to recur only in vineyards not treated for leafhoppers. If an outbreak does occur, the application of DDT dusts or sprays, as described for the grape leafhopper, is indicated.

If an outbreak should occur in a vineyard treated with DDT, indicating that the worms were resistant to DDT, lead arsenate should be used. Standard lead arsenate at 3 pounds per 100 gallons of water, applied about May 15 at 300 gallons per acre, will control the young worms that hatch from the eggs at this time. When the worms are nearly full grown they cannot be controlled by this spray. A dust composed of 25 per cent lead arsenate and 75 per cent sulfur (for mildew) may be applied at hatching time, but is not as effective as the spray. Lead arsenate should not be applied after the berries are formed.

Left to right, achemon sphinx moth; young achemon sphinx larva before losing the posterior horn.





WHITE-LINED SPHINX MOTH

Another pest that occasionally attacks grapes, especially in southern California, is the white-lined sphinx, *Celerio lineata* (Fabr.), which is similar and closely related to the achemon sphinx.

Appearance. This pest derives its name from the broad diagonal white stripe on the front wings of the moth. Larvae of the white-lined sphinx are bright green with broken, black longitudinal stripes down the back. Occasionally black larvae occur. They are about the same size as larvae of the achemon sphinx, but in addition to their variation in color and marking they can also be distinguished by a long yellow horn at the rear end of the body, which remains throughout the larval period.

Development and injury are similar to those of the achemon sphinx.

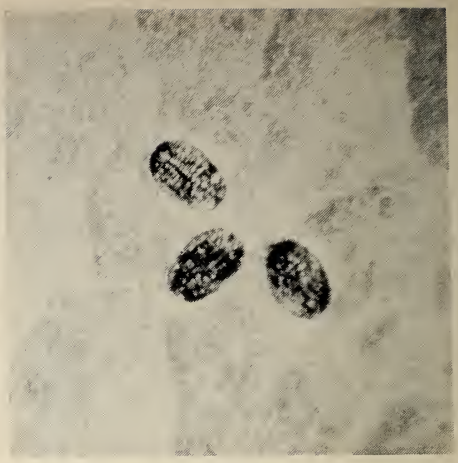
Control. The larvae can be controlled with several insecticides among which DDD is one of the most effective. A 5 per cent DDD dust applied by airplane to a wide strip bordering the vineyard will prevent the larvae from entering. If only the border rows are dusted, this pest will move only a few rows into the vineyard.

A ditch barrier along the border of the vineyard has been used. A plow may be used to make the ditch which should be from 14 to 18 inches deep with the steep side next to the vineyard. Post holes dug every 10 feet or so in the bottom of the furrow serve as places where the larvae collect and are easily killed.

GRAPE WHITEFLY

The adult whitefly, *Trialeurodes vittatus* (Quaintance) is a mothlike insect about $\frac{1}{16}$ inch long. It can be readily identified by its size and intense whiteness, which is caused by a dense, white waxy powder covering the body and wings.

Development. The adults lay their eggs on either the upper or lower surfaces of grape leaves. The eggs, so small they can be seen only with a magnifying glass, are attached to the leaf by a very short stalk.



Immature grape whiteflies on a grape leaf (magnified 5 times).

After hatching, the larvae crawl a short distance, then settle down to a motionless existence, usually on the upper surface of the leaf. During this stage they are difficult to distinguish from scale insects, especially young soft brown scale. They can be distinguished if the leaf is bent sharply beneath them, thus breaking the seal to the leaf, allowing the air to go beneath the insect and thereby making it more plainly visible. This does not occur with scale insects. The larva has a lemon-yellow body circled by a narrow white waxy fringe perpendicular to the leaf. During transformation to the adult stage the larva is dark brown with a white fringe.

When the larvae are fully grown they transform to the adult stage and emerge, leaving their discarded shells attached to the leaf.

There are several generations a year. This pest overwinters in the larval stage on various evergreen shrubs that compose our chaparral. In the spring adults may fly from chaparral areas to the vines

and establish an infestation. If the vines are infested early in the season, the whitefly may build up to enormous numbers, as it multiplies very rapidly.

Injury. The whitefly injures the fruit chiefly by soiling it with sticky excrement on which a black, sooty fungus develops.

Control. DDT applied for the control of the grape leafhopper will normally also control the whitefly. Backyard vines are more apt to become infested than commercial vineyards, since ornamental shrubs in the yard may provide a suitable host on which the pest can overwinter. Control in such cases should be centered on the ornamental shrubs; a 1 per cent lindane dust is effective.

INSECT VECTORS OF PIERCE'S DISEASE

In California there have been two serious outbreaks of Pierce's disease—one between 1880 and 1900, the other between 1935 and 1947—both associated with greater than normal rainfall.

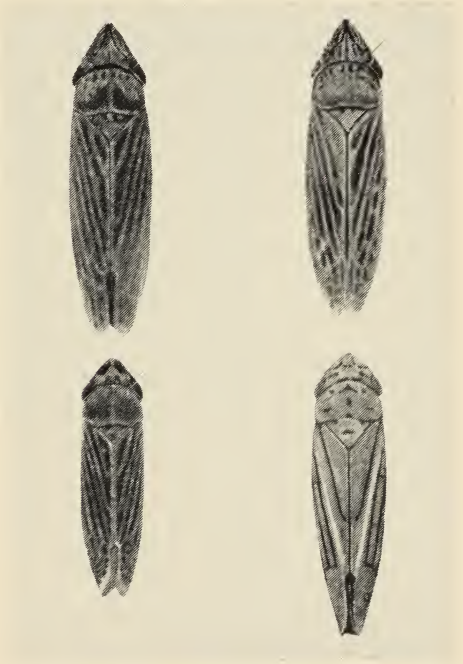
The virus that causes the disease may be transmitted from plant to plant by at least 24 species of insects. Of these, four are spittlebugs. Spittlebugs are so called because the young often surround themselves with a mass of white, wet froth. The remaining 20 vectors are all sharpshooters. Sharpshooters are a kind of leafhopper. The grape leafhopper, however, is not a vector of Pierce's disease.

The symptoms of Pierce's disease of the grape have been described as follows:

"1) Leaf scalding and later drying of the entire leaf, which usually starts after midseason; 2) wilting, withering, drying, and premature coloring of the berries on part of the vine or on the entire vine; 3) delayed foliation of a part of the vine or of the entire vine; 4) interveinal chlorotic mottling of the lower leaves (usually leaves 2 to 8) of the shoots; 5) dwarfing of the shoot growth of a part of the vine or of the entire vine; 6) failure of the canes to mature evenly; 7) gradual dying of the root system; and 8) death of the vine."*

Of the 24 vectors of Pierce's disease only three are important in transmitting the disease to grapevines. In the San Joaquin Valley the green sharpshooter, *Draeculacephala minerva* (Ball), and the redheaded sharpshooter, *Carneocephala fulgida* Nott., are of major importance. In coastal regions the blue-green sharpshooter, *Hordnia circellata* (Baker), carries the virus to the vines. These and the other vectors transmit the virus among the 73 plant species that are hosts and serve as virus reservoirs.

* Hewitt, W. B., N. W. Frazier, H. E. Jacob, and J. H. Freitag. Pierce's disease of grapevines. California Agr. Exp. Sta. Circ. 353:1–32. 1942.



Leafhopper vectors of Pierce's disease of grapevines (magnified about 11 times). Upper left, the green sharpshooter; upper right, brown form of the green sharpshooter; lower left, redheaded sharpshooter; lower right, the blue-green sharpshooter. (After Henry H. P. Severin.)

Throughout most of California **green sharpshooters** are green the entire year, but in certain regions of the state they turn brown in late fall, winter, and early spring. In the summer they are green again. The female is slightly over ¼ inch long and the color underneath is paler. The male is smaller and dark underneath.

The overwintered adult females lay eggs in weeds and grasses in the early spring. The young that hatch from these eggs are much the same shape as the adults but do not have wings. Three broods of sharpshooters are produced each year. This sharpshooter is most easily found in moist locations. Though it prefers to feed on grasses, it has been taken from more than 130 plants.

The **redheaded sharpshooter** female is about ⅕ inch long and its head is rounder than that of the green sharpshooter. It may be further distinguished by the reddish color of its head, although the body is green. The winter is passed in the adult stage, and there are four broods each year. It is found in somewhat less moist locations than the green sharpshooter.

While both the green and redheaded sharpshooters prefer grasses, they will feed on succulent vine growth in the spring. No reproduction takes place on grapevines.

The females of the **blue-green sharpshooter** are only slightly smaller than those of the green sharpshooter. They vary in color from green to bright blue on top and are yellow underneath. There are characteristic black marks on the upper surface.

The blue-green sharpshooter is found in heavy growth along streams, especially along the coast. It feeds and breeds on vines, shrubs, and trees, and is often found on ornamental plants in home gardens. This sharpshooter moves about considerably in seeking succulent food. On grapevines it is most frequently found feeding on the tips of the canes. It passes the winter in the adult stage, and there is but one brood each year.

Control of these insect vectors as a means of controlling Pierce's disease has not proved practical. The diseased vines are apparently not important in the further spread of the disease in the vineyard. Infection of additional vines appears to come from outside the vineyard. To protect the vines from sharpshooter attack for a whole season would prove very costly.

The only remedy for the disease is to remove the infected plants and replace them with healthy vines.

GRASSHOPPERS

Two species of grasshoppers of the genus *Schistocerca* attack grapes. These are the green valley grasshopper, *Schistocerca shoshone* (Thomas), usually found from Bakersfield northward, and the vagrant grasshopper, *Schistocerca vaga* (Scudder), which is found from Fresno southward.

A third species particularly harmful to the vineyard is the devastating grasshopper, *Melanoplus devastator* Scudder, which occurs chiefly in the low foothill areas in the Sierra and Coast Range and is found throughout the length of the state.

Various other species are occasionally found in vineyards but rarely cause commercial damage. Their life cycles are similar to the devastating grasshopper's, except that they lay their eggs before the fall rains start and are not limited to the foothill regions.

Appearance. The green valley grasshopper is easily recognized by its leaf-green color, red hind legs, and a yellow stripe along the midline of the head and thorax. It is one of our largest grasshoppers. The females are about 2½ inches long and the males measure about 1½ inches.

The vagrant grasshopper is about the

Below, adult green valley grasshopper and, at right, an adult devastating grasshopper. (Both are approximately natural size.)

same size but is easily recognized by its brown body, brown legs, and a tan stripe along the midline of the head and thorax. The front wings are tan with brown mottling.

In its immature stage the devastating grasshopper varies from straw-colored to brownish-black, with darker stripes on the sides of the head and thorax. The adult averages just under an inch in length, is amber to brownish in color, and has dark markings on the thorax and a row of dark spots on the front wings. The shank of the hind leg is blue at the base and shades gradually to amber at the tip.

Development. Both the green valley and vagrant grasshopper lay their eggs in May. The eggs are laid in masses in a hole in the ground, which the female bores by inserting her abdomen into the ground as far as possible. The eggs are embedded in a frothy material that soon hardens in a spongelike structure. These

egg masses of the grasshopper are called pods. Each female lays several pods. Within a few weeks the eggs hatch into young, wingless hoppers, which burrow to the surface and commence feeding on plant foliage. They grow slowly through June and July and reach the winged adult stage in late summer.

The devastating grasshopper, on the other hand, lays its eggs in the ground in the fall, after the first rains. The adults all die in the fall or early winter, and only the eggs survive. The overwintered eggs hatch during the following May, June, and July.

All three species, thus, have only one generation a year.

Injury. After passing the winter in hibernation in the adult stage, green valley and vagrant grasshoppers become active in the spring, when they may enter the vineyards in great numbers and, by feeding on the young shoots, defoliate the vines.

The devastating grasshopper does its damage usually in mid- to late summer when grasslands dry up. By this time the winged adults are present, and they fly from their breeding grounds into the vineyards in search of green foliage.

Control. All kinds of grasshoppers may be controlled by spraying with TEPP (tetraethyl pyrophosphate), using thorough coverage and applying 1 to 2 pints of 20 per cent TEPP per acre, depending on the size of the vines. This chemical is so quickly dissipated that no poisonous residue can be found on the fruit a few days after spraying. Several other excellent insecticides for grasshoppers, such as aldrin, dieldrin, toxaphene, and chlordane, are not approved for use when fruit is on the vine because of their long-lasting poisonous residues. Dieldrin may be used after harvest for green valley and vagrant grasshoppers which overwinter in the adult stage.

If large numbers of wingless hoppers are found on rangeland adjacent to the vineyard, it may be feasible to control them in such fields by using poison bait. Dry baits are recommended in dry foothill areas where leaf-surface area is small in comparison with the ground surface. Such baits are prepared by mixing wheat bran with a poison. For each 100 pounds of bran, ½ pound of chlordane should be used, or 1 pound of toxaphene, or 2 ounces of aldrin. The poison should be dissolved in ½ gallon of kerosene or diesel oil and then thoroughly mixed with the bran. The bait should be spread uniformly at 5 to 10 pounds per acre.

Damage caused by devastating grasshoppers feeding on leaves and canes.

Flowers and Fruit

HOPLIA BEETLE

Hoplia beetles, *Hoplia oregona* Le Conte, are often noticed first on the flowers of many plants. They are particularly attracted to white flowers—roses, lilies, orange blossoms, and the blossoms of deciduous fruit trees. When disturbed, these beetles are quick to feign death and fall to the ground, even though they are strong fliers.

Appearance. Adults are ¼ to ⅓ inch long and are robust. The abdomen of the female is thicker than that of the male, which is almost flat. On the upper side the beetles are mostly reddish-brown with darker heads. The underside is silvery and shiny. Large variations in color and size occur, however, even among beetles that have emerged from a very limited area of ground.

Development. During June the beetles die of old age after laying their eggs in the ground. The larvae hatching from the eggs are grubs that feed on the roots of alfalfa, lawns, and other plants, including roses. The grubs are whitish and curved in a "C" shape. They have six short legs at the anterior end and a swollen, bulbous posterior. The grubs pupate in the soil in early spring and change over into the adult form. On emerging from the soil in the spring, the new adult beetles often leave round exit holes. They immediately fly some distance to flowers and vines to feed and mate. Often good sources of food are passed over in this dispersal flight. Some must return to lay eggs, however, as hoplia beetles have been observed to emerge year after year from the same limited area.

Injury. Often the beetles feed in groups so that severe damage in a vineyard may be very spotty. In certain regions of the San Joaquin Valley, however, the loss of crop has been severe.

About the time the new shoots are 12 to 14 inches long, the beetles fly into the vineyards and feed on the forms or developing bunches and young leaves. This usually occurs before the forms are more

Adult grape hoplia beetle (about 4 times natural size). Below, larva or white grub of grapevine hoplia.

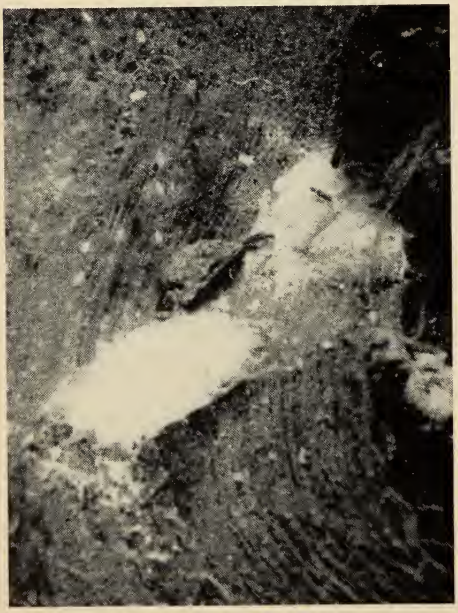
than 3 inches long. Partial destruction of the fruit forms caused by their feeding results in small, misshapen bunches at harvest.

One or two weeks after their first appearance in the vineyard, certain vines, often at the end of vine rows, may show considerable foliage damage from the gregarious feeding of the beetles. About this time the beetles stop feeding on the forms, and the vines produce foliage so rapidly that the beetles do but little further damage.

Control. Lindane dust will control these beetles. A 1 per cent dust should be applied at the rate of about 15 pounds per acre as soon as feeding on the forms is noticed. DDT dust for leafhopper control apparently has little effect on hoplia beetles.

GRAPE MEALYBUG

Grape mealybugs can quickly turn a bunch of grapes into a sticky, sooty mess. This insect, *Pseudococcus maritimus* (Ehrh.), is also found on many native and cultivated plants. On grapes the mealybugs in various stages of development may be found on leaves and stems, in the bunches, or under loose bark. Their greatest damage is to the fruit.



Mealybug egg sac and young under grape bark.

Appearance. Mature mealybugs are about $\frac{3}{16}$ inch long and are covered with uniformly distributed, fine, white, waxy powder. Fine filaments of wax stick out from the margins of the flat bodies. The filaments at the posterior end are much longer than the others but never longer than half the body length.

Development. Grape mealybugs pass the winter as eggs or very young stages in cottony egg sacs under loose bark on the trunks and arms of the vines. With the approach of spring the young move toward the buds to feed on the new, tender growth. By June the mealybugs have matured and are laying eggs. The eggs are laid in a loose, cottony wax sac which the female carries about. In most cases the females move to the bark before depositing their egg sacs. Hatching takes place in June. Sucker growth touching the old wood in the crowns of vines and grape bunches resting against the old wood make excellent places for the young to feed and develop. It is the June-hatched generation of mealybugs that does the most damage.

The next brood of eggs is laid in late summer and fall, and the young mealybugs that hatch from these eggs form the overwintering stages. There are thus two broods a year.

Two factors operate to keep the grape mealybugs from increasing to such numbers as to cause large losses. First is the temperature at the time of the June hatch. If the temperature is high enough most of the crawlers may be killed. However, if the mealybugs become large enough before very hot weather occurs, they will not be killed. Many insect parasites and predators also help reduce the grape mealybug population. In many

areas these natural enemies are sufficient to hold the grape mealybug in check. However, ants, which often visit the mealybugs to collect the sweet honeydew (excrement) they secrete, will keep parasites and predators away and permit the mealybugs to increase.

Injury. The honeydew secreted by both young and adult grape mealybugs collects in drops wherever it lands on the vines. It may be found inside the bunches where the mealybugs are feeding. Drops of honeydew may collect on the bunches in such quantity as to run and drip. The drops of mealybug excrement are much larger than those of the grape leafhopper whose honeydew does not collect in sufficient quantity to run and drip. This sticky liquid supports the growth of a black fungus that gives the leaves and bunches a sooty appearance. Mealybug infestations in the bunches may cause the berries to crack, permitting the easy entrance of spoilage organisms. From the standpoint of appearance alone, the sooty, sticky bunches with whitish mealybugs and their cottony wax masses are valueless as table grapes.

Control. Control of mealybugs is difficult because their waxy secretions prevent contact with many insecticides that might otherwise poison them. If parasites and predators are present in sufficient numbers but are driven away by ants, the use of poison baits to control the ants will permit effective control of the mealybugs by their natural enemies. The widespread use of insecticides for other grape pests may also reduce beneficial parasite populations. In this case ant control would be of no value.

A control of long standing is a spray of 4 gallons of liquid lime-sulfur plus 3 gallons of either dormant emulsifiable oil or dormant oil emulsion per 100 gallons of water. This spray should be applied in early spring before bud swell.

Good control may be obtained with a dormant spray of 1 pint of emulsifiable parathion concentrate (4 pounds of actual parathion per gallon of concentrate) per 100 gallons of water. With either spray, thorough coverage is necessary.

In applying parathion sprays the object should be to obtain a heavy, even deposit. This is best done by using a low pressure (200 psi or less) and a large disk opening (No. 8 or larger) in the spray gun. Spray should be used at the rate of 1 to 1¾ gallons per vine. Large vines with heavy, loose bark require a larger amount of spray. The parathion may be combined with sodium arsenite to control both mealybugs and black measles of grapes at the same time.

If the mealybug infestation is very heavy, a spray of 2 pints of emulsifiable parathion concentrate per 100 gallons of water applied at the rate of 1 gallon per vine will be necessary for control.

Parathion dust will give some control when applied the last of June or first of July. Two per cent parathion dust should be applied at the rate of about 30 pounds per acre. A second application after about 10 days may be necessary.

GRAPE THRIPS

Grape thrips, *Drepanothrips reuteri* Uzel, are tiny yellow insects about 1/32 inch long. They do their greatest damage by scarring the berries and rendering the fruit unsightly and unfit for the table market. They also feed on the leaves and on the green tender shoots.

Development. Grape thrips emerge from hibernation about the time the buds open in late March. Apparently only females overwinter, and they do so under the bark of the vine, in dried leaves and rubble around the base of the vine, and in the soil. Overwintered females feed on the leaves in the spring for about 20 days, during which time they lay many eggs, inserting them shallowly under the skin of the leaves and stems. The first larvae hatch out early in April.

Left, scarring on malaga grapes caused by grape thrips. Right, late summer damage to grape leaves caused by grape thrips. (Photographs by S. F. Bailey.)

Breeding is speeded up by the warmer temperatures of summer, and by midsummer the grape thrips completes a generation every 22 days. About six generations are completed each season, and the peak of abundance normally occurs about the last week of July. As the vine growth slows down, favorable succulent leaves are fewer, and the thrips population dwindles. The adults have wings and readily take flight on warm days. Consequently, they are easily dispersed over a wide area by even a slight breeze.

Injury. Fruit damage is done early—usually by the time the fruit is one-third grown. Both adults and larvae are responsible, but the larvae, feeding in small groups, do the most damage. In summer they concentrate on the tender tips of the canes and unfolding leaves, doing almost no feeding on the berries.

When the infestation is severe, the tips of the canes may be stunted or killed, and all new leaves put out on the periphery of the vine after June are curled and present a scorched appearance. If the grapes are sent to the winery, the scarring of the berry skin is of little importance.

Control. DDT dusts and sprays applied for the control of grape leafhopper have kept the grape thrips under control in recent years.

GRASS THRIPS

Grass thrips feed and breed on practically all plants, and three common species—*Frankliniella occidentalis* (Perg.), *F. moultoni* Hood, and *F. minuta* (Moulton)—may occur in the vineyard. They are especially fond of the forms and tend to concentrate in them before blooming time.

Two other species—the bean thrips, *Hercothrips fasciatus* (Perg.), and the citrus thrips, *Scirtothrips citri* (Moulton)—occasionally damage grapevines.

Grass thrips (approximately 32 times natural size).

SEASONAL CHART:

On the inside pages of this special section is a quick reference chart to help you identify pests by the damage they do at various periods. Reference to appropriate control measures is given so that you can quickly find what is recommended for your locality and for the conditions pertaining in your vineyard. This chart may be removed from the circular and hung on a wall as a handy guide.

IN BRIEF . . .

Grape pests—how to identify them and
reference to appropriate controls . . .

For a number of the pests listed, control measures are various. The method used may depend on the growth cycle of the vine, the insect, or both. Methods may also vary from one region to another. For effective control, read the passages referred to.

SEASON	DAMAGE	PEST	FOR CONTROL MEASURES SEE PAGE
Midsummer— June July August	Leaves pink or light brown, dry; basal leaves with fine black excrement	Grape leafhopper	10–12
	Leaves red or brown, dry	Pacific mite	14
	Leaves bronzed	Willamette mite	15
	Leaves sticky, wet	Mealybugs Soft scales White flies	31 36–37 25
	Leaves red along main veins	Rust mite	23
	Leaves with pencil-sized rolls	Grape leaf folder	18
	Leaves eaten	Grasshoppers Sphinx moth	28 23–25
	Leaves with slit-like holes; grooves in fruit	Western grape rootworm	53
	Vines weak; new growth dwarfed	Nematodes	51
Late summer— August September	Berries with sooty black dots	Grape leafhopper	10–12
	Berries wet, sticky, with white cottony masses	Grape mealybug	31
	Leaves and berries eaten	Grasshoppers	28
	Berries scarred	Grape thrips	32
	Berries punctured, bleeding; internal breakdown	Consperse stink bug	34

Spring— March April May	Buds chewed at opening time	Cutworms Bud beetle Click beetle Flea beetle	44–45 46 47 48
	Defoliation	Grasshoppers	28
	Buds fail to open; shoots stunted	Bud mite	43
	New leaves stunted, yellow or black; shoots long, straight	Willamette mite	15
	New leaves stunted; shoots stunted, zigzag, and scarred	Grass thrips	33
	Tender shoots chewed	Little bear beetle	48
Early summer— May June	Leaves with white flecks	Grape leafhopper	10–12
	Yellow areas on leaves	Pacific mite	14
	Wilted leaves, small spots of dark excrement	False chinch bug	22
	Shoots wilted or broken off	Branch and twig borer	35–36
	Leaves eaten except main veins	Western grape skeletonizer	20
	Leaves eaten completely	Sphinx moths	23–25
	Forms and flowers eaten	Hoplia beetle	30
	Red or green blisters on leaves	Erineum mite	21
	Vines weak; shoots dwarfed	Phylloxera	50
	Trunk girdled at ground level	Darkling ground beetle	39

The bean thrips has occasionally been injurious in unirrigated vineyards. The citrus thrips has been found in vineyards only in hot, dry areas where citrus trees were growing near the vineyard. The injury produced by both resembles that of the grass thrips, and the control is the same as that recommended for the grass thrips.

Appearance. Grass thrips vary in color from yellow to dark brown. They are about $\frac{1}{32}$ inch long. If an infested form is struck sharply against the palm of the hand, the thrips are dislodged and can be seen running rapidly over the hand.

Development. Grass thrips continue to breed throughout the winter when temperatures are fairly high. They occasionally reach considerable numbers on the weeds or cover crops in the vineyard. When these are disked under, the thrips move into the vines and may produce severe injury in a few weeks. If the thrips have built up in nearby grassland or pasture, they may migrate into the vineyard in great numbers as the grass dries up.

Injury. Grass thrips produce scarring and dwarfing of new shoots in the early spring. The shoots bend at the nodes to form a zigzag. The leaves are stunted and have a slight silvery sheen. The scarred areas often break through the leaf to form holes.

In addition, by feeding on and scarring the cap stems of the future berries, the grass thrips interfere with the set of fruit, and the result is a stringy, loose bunch.

Control. Although the grape thrips is normally controlled by DDT applied for the control of the grape leafhopper, the grass thrips often do their damage before leafhopper control would be applied. Therefore, if grass thrips appear in damaging numbers, a 5 per cent DDT dust should be applied immediately. Usually the first sulfur dust for mildew coincides with grass thrips damage, and the application of a sulfur-DDT combination dust will accomplish both purposes.

CONSPERSE STINK BUG

In the late summer and early fall consperse stink bugs, *Euschistus conspersus* Uhler, may invade a vineyard in countless numbers. They suck juices from leaves and petioles, but this results in negligible damage to the vine. They also feed readily on the ripening berries and thus cause considerable loss of crop.

Appearance. The adult stink bugs are about $\frac{3}{8}$ inch long. They are brown and have amber-colored legs on which are minute black spots. The underside of the body is yellow or pale green. The body is hard and shield-shaped. The adult bugs have wings and can fly considerable distances.

Development. This pest passes the winter in the adult stage, hibernating under trash on the ground. Emerging from hibernation early in April, they feed on many different kinds of annual plants and lay their eggs on these plants. The white eggs are laid in groups of 10 to 20, and each egg has a row of small

Adult consperse stink bug (about 4 times natural size). Note the black spots on the legs.

Damage caused by the consperse stink bug. Note spots where juice has oozed from stink bug punctures.

spines around the top edge. Egg laying continues through April and May. The young bugs that hatch from the eggs are wingless and feed on a variety of broad-leafed weeds, especially mustard, dock, mullein, and plantain. These young bugs reach the adult stage during July, August, and September. In their turn, they lay eggs that develop into adults in September and October. The adults of the second generation (and possibly some of the first) hibernate during the winter.

Injury. Consperse stink bugs feed by inserting their sucking mouthparts into the ripening berries. From each puncture the berry bleeds, forming a brown, sticky, unsightly mass. These feeding punctures cause a rapid internal breakdown of the berry, which soon shrivels and may become moldy.

Control. Since invasion of the vineyard occurs near picking time, control of this pest with chemicals in vineyards is not feasible. Poisonous chemicals cannot be used in the vineyards at this time because a residue would remain on the harvested fruit. Hordes of adult bugs have been known to enter vineyards in September and early October following late cutting of adjacent alfalfa fields. Similar migrations may occur in midsummer as grasslands and pastures dry up. When large populations of stink bugs are known to exist in fields adjacent to the vineyard. chemical control of the bugs in these fields, prior to migration, is suggested. Thorough spraying with parathion (1 pound of 25 per cent wettable powder) or lindane (1 pound of 25 per cent wettable powder per 100 gallons of water) will kill these bugs. Whether or not these materials may be used in adjacent fields will be determined by the nature and intended use of the crop.

The Canes, Arms, and Trunk

BRANCH AND TWIG BORER

When numerous, these beetles, *Polycaon confertus* Le Conte, have killed more than half of all the new shoots in some vineyards.

Appearance. The brown or blackish females are cylindrical and about ⅔ inch long. The male is smaller, about ⅓ inch long, and is frequently found in attendance while the female feeds.

Development. The eggs, which are cylindrical and slightly pointed at one end, are laid singly in cracks and crevices in the rough bark on the arms or occasionally on the trunk. The white, wood-boring larvae that emerge have three pairs of stubby legs near the brown head. The body is enlarged near the head end.

Once established in the trunk or arms of a vine, the grubs feed for nearly a year, and when full-grown, usually in April, they burrow to a position near the tip of the arm where they prepare a hollow cell in which to pupate. After a week or two in the pupal stage the adults emerge.

Injury. In the spring when the new shoots are 8 or 10 inches long they may wilt or break off in a wind storm and hang down, attached to the spur. Close inspection of such wilted shoots may show a hole bored in the crotch formed by the shoot and the spur. This hole represents a feeding puncture made by the adult of the branch and twig borer. Careful examination of the vines at this time will reveal the beetles engaged in this type of feeding. The feeding puncture is often deep enough to contain the entire beetle, or the tip of the body may protrude from the hole.

The larvae do equal damage, boring into the wood in dead or dying areas. Once established, however, they feed with equal ease on both living and dead wood. As they progress slowly through the wood they plug the burrow behind them with frass (excrement) and chewed wood. This material looks like very fine, tightly packed sawdust. As many as 20 grubs may occur in a single arm.

Control. No method of killing these pests with chemicals has been devised

Branch and twig borer: left, pupa; center, larva; right, adult (about 6 times natural size).

Work of the branch and twig borer in grape wood. The tunnels are normally plugged with chewed wood, but the plug has been removed from one tunnel in the upper left section to show the type of burrow.

because cultural control methods are entirely satisfactory. Since the newly hatched grubs enter the vine through dead and dying areas on the trunk and arms, they can be controlled in part by keeping the vines healthy and pruning out all dying and dead parts.

Damage by this pest can best be prevented by burning all infested wood in the winter. Experience has shown that severe damage to vines usually occurs in the vicinity of wood or brush piles. These insects feed in the wood of many orchard trees and ornamental trees and shrubs, including acacia, almond, apple, apricot, currant, fig, grape, manzanita, oak, olive, peach, prune, and others. Consequently, such wood—and especially infested wood from grapevines—should not be piled beside the vineyard. All such wood should be burned before March, while the pest is still in the grub stage.

SCALE INSECTS

The scale insects are rarely of economic importance in California. Many of them have been found living on grapevines, however, and control measures are occasionally necessary.

These scales may be separated into two groups—those that may feed in more than one part of the vine and those that remain stationary after selecting a place to feed.

All scale insects of the first group secrete a sugary liquid excrement. (Other grape pests that produce a sugary excrement are mealybugs and whiteflies.) When mature, the scales of this group are $\frac{1}{5}$ inch long or more. The group includes the cottony cushion scale, soft brown scale, cottony maple scale, brown apricot scale, frosted scale, and black scale.

An individual of the second group feeds only in the spot on the vine where it first settles. These scales never become larger than $\frac{1}{10}$ inch in diameter. This group includes the oystershell scale, oleander scale, olive scale, California red scale, Florida red scale, greedy scale, grape scale, San Jose scale, and walnut scale.

Brown apricot scale. An example of the first group of scale insects is the brown apricot scale, *Lecanium corni* Bouché.

The adult females are brown, from $\frac{1}{8}$ to $\frac{3}{16}$ inch long, and nearly hemispherical in shape. They may be found on leaves or bunches, but most of them occur on the stems of the current season's growth or on one- to three-year-old wood. Eggs are laid beneath the body which gradually shrinks against the outer body wall to form an egg-filled pocket. As more eggs are laid, the body walls of the scale become hard and, after death, very brittle.

The winter is spent on one- to three-year-old wood as small immature stages. There is only one brood a year.

This scale produces a great deal of honeydew that makes grapes sticky and sooty in the same manner as does the

honeydew produced by the grape mealybug.

Control may be accomplished in the dormant season with lime-sulfur and oil spray or other sprays used for dormant control of the grape mealybug. An oil and nicotine spray may be used to control the young scale on the leaves in the summer. Sprays—especially oil sprays—applied after the berries have reached buckshot size may cause fruit spotting and loss of waxy bloom.

Cottony maple scale. In this state the grape grower seldom sees the white cottony masses or egg sacs that the cottony maple scale, *Pulvinaria vitis* (Linn.), produces in May and June. An occasional vineyard or backyard vine does require control measures, however.

The female cottony maple scales that produce the egg sacs are found on canes produced the previous season. As the scale continues to lay eggs, the sac is enlarged. Each female lays about 3,000 eggs. The sacs remain for some time after the female dies, the eggs have hatched, and the minute young have crawled to the undersides of the leaves.

The small immature scales are yellowish or greenish. They feed by inserting their long thin mouthparts into the living tissue and sucking up the plant juices. Their sugary liquid excrement, falling on the leaves below the scale colony, makes the leaves and fruit look wet and shiny. The excrement also supports the growth of a black sooty fungus that makes the bunches very unattractive. This excrement is attractive to ants which feed on it. The presence of ants and shiny or sooty leaves is frequently noticed before the scale insects themselves are seen.

In late July and early August the males develop into very small adults with wings. After mating, the wingless females crawl back to the young canes where they spend the winter. At this time they are about 1/7 to 1/6 inch long, flat, and oval in outline. The color is brown. Full size is reached in May when the scales attain a length of about 1/5 inch.

Where backyard vines have not been sprayed in the winter, the females and their egg sacs may be dislodged by a strong stream of water early in the spring. Otherwise, control is the same as that for the brown apricot scale on grapes.

Grape scale. The grape scale, *Diaspidiotus uvae* (Comstock), is an example of the second group of scale insects. It gives vines a dirty white appearance when the infestation is very heavy. Any place on the trunk, arms, or canes where the scales can reach living tissue with their sucking mouthparts may be infested. Most of the scales are found on the two-year-old canes. When abundant, they may cause a severe stunting of growth.

Each female produces 35 to 50 living young. These very small insects crawl under the loose bark of the previous season's growth and settle mostly in rows. After settling, this scale feeds on no other spot on the vine. The winter is passed in a half-grown condition.

Brown apricot scale.

Cicadas and damage. Note the white wood fibers pried from the canes in the process of making egg punctures.

Control of the grape scale and other scales that infest vines is best obtained by winter sprays. Dormant oil emulsion at the rate of 4 gallons per 100 gallons of water may be used. Dormant sprays for control of grape mealybug will also control scale insects. The loose bark should be removed before spraying whenever practical. Thorough spray application is essential. Since most of the scale overwinter on the younger wood, a severe pruning will be very helpful in reducing the scale population.

CICADAS

Cicadas are well known because of the loud clicking or buzzing noises they make on warm summer afternoons. Although everyone has heard them, few have seen them in spite of their large size. When approached, they dodge around a limb and always stand on the opposite side from the observer.

One of the smaller species, called the minor cicada, *Platypedia minor* Uhler, occasionally injures grapes.

Appearance. The adults of the minor cicada are about ¾ inch long with black or bronze-black bodies and two pairs of large, colorless, transparent wings. They produce a loud clicking noise that sounds like two glass marbles struck together rapidly.

Development. Egg-laying activities begin late in April when the adults emerge. The females are provided with

a strong, saw-toothed rod on the hind end of the abdomen with which they can drill holes into the hardest wood. They drill holes into grape canes to prepare niches to hold their eggs. After a hole has been cut, the female lays four or five eggs in it, then moves forward about a quarter of an inch and repeats the performance, until a row of five to ten such punctures results.

The eggs hatch in a week or two, and the young make their way to the ground and burrow in. The front legs of the young cicadas are greatly enlarged for digging in the soil. They may burrow to depths of 3 or 4 feet. Here they feed on the roots of various plants.

From two to three years are spent below ground before the young are fully grown and ready to transform to the winged adult. The young cicada then leaves the soil and crawls up a few inches on grass, fence posts, etc., the skin splits down the back, and the adult emerges, leaving its old skin intact and firmly attached to its support.

Injury. The damage of the minor cicada is caused by the females as they carry out their egg-laying activities. Each puncture of the grape cane is made conspicuous by slivers of wood protruding from it.

Whether or not the young, during their life underground, feed on the roots of grapes has not been proved. It is known that they feed on the roots of French prune and also that when prunes and grapes are both available, the females prefer to lay their eggs in grapes. This would indicate that the young cicadas probably do feed on the roots of the vine.

Control. Control of this pest is achieved by normal cultivation. When the young cicadas are fully grown, they make their way upward during February to positions an inch or two below the surface of the soil. Disking the soil before the emergence of the adults during the last two weeks of April crushes many of them and appears to interfere otherwise with their emergence. Pruning canes to a short spur in the winter and thereby removing many visible egg punctures is of no value in control of this pest because the eggs have long since hatched. If cultural control has been neglected and it becomes necessary to resort to chemical control, the adults can be killed with a spray of commercial TEPP, using 1 pint per 100 gallons of water. These pests are resistant to parathion, DDT, and related compounds.

DARKLING GROUND BEETLE

Darkling ground beetles (several species of the genus *Blapstinus*) damage young vines by feeding on wounds on the trunk occasionally made by cultivating tools. They may start to feed on the fresh, succulent tissue exposed by a recent cut, or if the wound has started to heal, they will feed on the callous tissue. In either case, they extend the wound slowly around the trunk and to a lesser extent up and down the trunk, feeding through to the wood cylinder and eventually girdling the vine. Such girdles are often 2 to 3 inches wide.

The larvae live in the soil and are called false wireworms. They feed on the

Darkling ground beetle (about 9 times natural size).

roots of grasses and occasionally damage truck crops. The larvae do no damage to vines, however, since they prefer to remain in the upper, dry 2 to 3 inches of soil and do not penetrate to the depth of the vine roots. It is only in the adult stage that they damage the vine.

Control consists of dusting the soil liberally over a circular area extending about 3 feet from the vine with a 70 per cent sodium fluosilicate dust or a 5 per cent DDT dust.

TERMITES

The grape grower is especially aware of termites because he must drive wooden stakes into the ground to support young vines or erect braced posts to support a wire trellis. However, the damage done to living grapevines may go unnoticed until an arm or a whole vine is accidentally broken off as a result of termite infestation.

The species that attacks the vines is called the subterranean termite, *Reticulitermes hesperus* Banks. There are several other species in California, but they have not been found in vines.

Appearance. The adult sexual forms, seen during swarming, are black with two pairs of long slender wings. They are frequently believed to be flying ants, but can easily be distinguished from ants by their broad waists, whereas ants have a very slender, threadlike waist.

Development. The subterranean termite swarms after the first fall rains. Swarming is the mating flight of the winged sexual forms.

After a short flight, the males and females associate in pairs on the ground and break off their wings. Each pair becomes king and queen of the new colony that they intend to establish. They excavate a small hole in the ground and raise a brood of wingless workers.

This first brood of workers is fed on regurgitated stomach contents of the parents. As soon as the workers are able, they seek edible wood in the vicinity of their nest. Wounds exposing the heartwood, old beetle holes, or decayed pruning saw cuts are necessary for entry of termites into the vines.

Injury. In their attack on the vine, the termites eat the heartwood and avoid the living sapwood. Termites will live for years in the heartwood core and only slightly penetrate the outer, surrounding sapwood. Usually the entire core of the wood is honeycombed, and its structural strength so weakened that breakage occurs with the least unusual strain.

Old vines show more termite damage than young ones. In some districts vineyards 40 years old and older are 100 per cent infested with termites. They have had much greater opportunity to become infested, and in old vines the protective sapwood becomes much thinner. Surface injuries and heavy saw cuts then expose more of the acceptable heartwood for possible termite invasion.

Control. Control of termites is a matter of prevention. Care should be taken to avoid scarring the vines with cultivating tools. Saw cuts 12 inches or more above the ground are probably rarely a point of entry, unless the heartwood is softened by wood-rot fungi or reduced

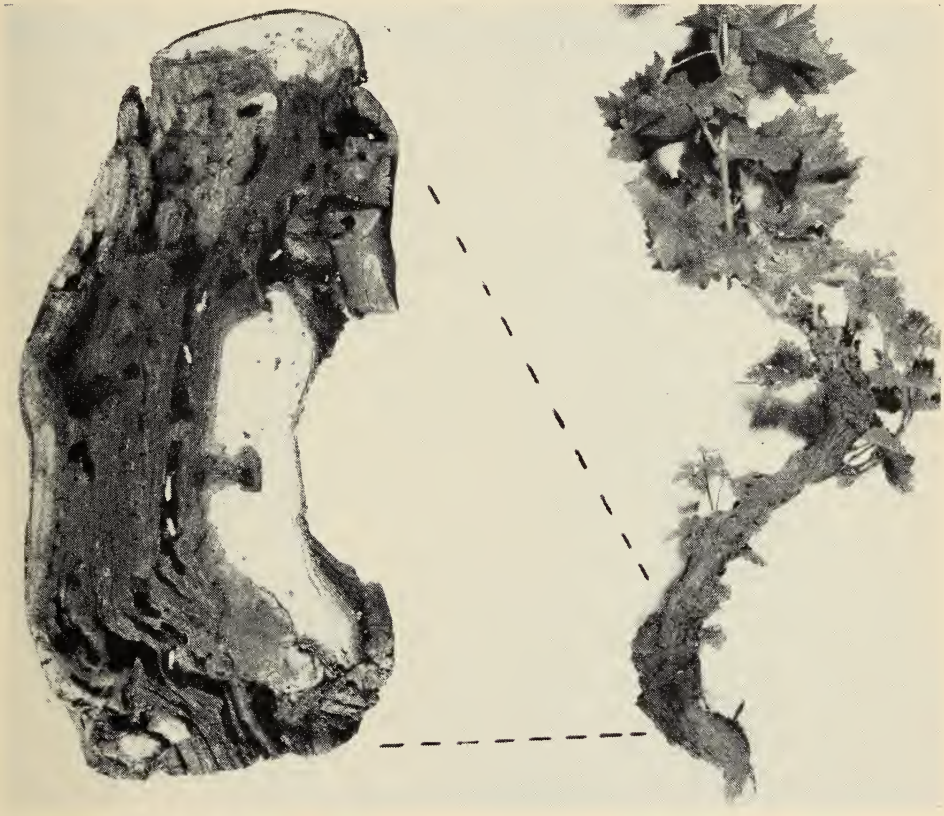
Cross section of an arm of a grapevine showing how termite work is normally confined to the dead brown heartwood.

by branch and twig borers, in which case the king and queen may establish their nest there as though it were soil.

Stakes are normally heartwood of redwood, but, when possible, may be made from discarded cedar telephone poles, as the heartwood of cedar is quite resistant to termites. When other, nonresistant woods must be used, they should be treated with chemicals to protect them against both termite and wood-rot fungi.

The old method of treating stakes was to apply two coats of hot coal-tar creosote, like a paint; or the stakes were dipped in a vat of hot creosote. Much more lasting protection is afforded by the newer practice of forcing the creosote into the wood, that is, impregnating it in large pressure cylinders. In this process the wood should absorb 10 pounds of creosote per cubic foot of wood.

Several new compounds have recently come into use which appear to have some advantage over coal-tar creosote. One of these is pentachlorophenol. This material is dissolved, 5 per cent by weight in 95 per cent by weight of petroleum oil, and the wood is impregnated in pressure cylinders until each cubic foot of wood contains 8 pounds of the solution. Another new development is copperized chromated zinc chloride. This is handled as a solution, and the wood is impregnated so that each cubic foot contains 1 pound of the dry compound.



Termite damage to grape wood. Note that the new cane growth on the arm at the right is nearly normal. At the left is a longitudinal section of the marked portion of the arm, showing the extent of termite invasion and the small amount of white living wood.

The Buds and Very Young Shoots

GRAPE BUD MITE

In many grape-growing areas in California there occurs a strain of erineum mite, *Eriophyes vitis* (Pgst.), that lives within the grape buds.

Appearance. This strain is indistinguishable from the erineum mite, described on page 20, except that it does not live on the leaves or cause the leaves to produce felty patches of plant hairs.

Development. The mites pass the winter as adult females in the grape buds. The depth to which they penetrate the bud varies from two or three outer bud scales to the innnermost central growing point. Egg laying starts as the buds begin to swell in the spring. As the new shoots elongate, many eggs and young mites are carried out with the bud scales, which become bracts at the bases of the leaf petioles close to the new buds. As the new buds develop, the mites move in under the bud scales.

In June the mites apparently move about so that any bud on the cane may become infested. More mites and deeper penetration of mites into the buds occur on the basal portion of the cane. The greatest numbers of mites are found in the fall, and the population gradually decreases through the winter months. Pruning removes many mites but leaves on the vine the buds with the greatest adult mite infestations.

Bud mite injury on muscat grapes, showing distorted, branched shoots.

Injury. Infested buds show typical blisterlike growths on the inner surfaces of the bud scales and on embryonic leaves. On the innermost growing point of the bud dead tissue may be seen where the mites are feeding. Buds from the basal portion of grape canes have been forced out in the winter by placing them in a warm place with the bases of the canes in water. Buds that failed to grow or that showed abnormal growth symptoms were, in most cases, those infested with bud mites.

In the field many cases have been observed where heavy infestations of bud mite were associated with thick cane growth, shortened nodes, short scraggly bunches, and many bud failures. In the spring heavy infestations of mites are often found in buds that have failed to grow, while shoots that have attained normal growth show little or no infestation.

Identical or very similar growth symptoms have been observed where no bud mites were present. In these cases the symptoms were reduced and yields increased by pruning at a favorable time. In southern California the malady is believed to be physiological. In Sonoma County vines have responded to a favorable pruning time in both the presence and absence of bud mites. This pruning-time response has not occurred in experiments in the Central Valley.

Control. In experimental tests to date, control of the bud mite with chemicals has not been successful. Various chemicals, applied in winter, will penetrate into the buds and kill the overwintering mites, but all chemicals that have been tested also damage the bud. Sulfur, which readily controls the erineum strain, is of no value for bud mite control.

CUTWORMS

Damage to buds by cutworms in the early spring coincides with similar damage by bud beetles and click beetles. The

Greasy cutworm.

click beetle may be easily observed, since it feeds on the buds in full daylight. The cutworm and bud beetle are more insidious, hiding during the day and emerging after dark to do their feeding. While positive identification is not necessary, since chemical control is similar for all three pests, a knowledge of their individual habits and methods of operation is desirable for effective control.

Cutworms are larvae of moths that fly at night and hide during the day. Though many different species attack grapes, the three common ones are the variegated cutworm, *Peridroma margaritosa* (Haworth), the greasy cutworm, *Agrotis ypsilon* (Rothemburg), and the brassy cutworm, *Orthodes rufula* (Grote). Of these three, the variegated cutworm is the one most often found.

Appearance. Cutworms are dull colored and characteristically marked with faint spots or lines. The smooth bodies attain a length of 1 to 1½ inches

Variegated cutworm.

when fully grown. They have three pairs of true legs near the front end of the body and five pairs of short stubby "prolegs" on the abdomen. One of these pairs of prolegs is attached to the last segment of the body.

The color of the variegated cutworm varies from ashy gray to brown, with a light mottling of darker brown. Down the backs of the larvae there is a pale yellow dot in the middle of most of the segments. The moths have grayish-brown forewings measuring from 1½ to 2 inches when spread. The hind wings are clear except for darker margins.

The larvae of the greasy cutworm are dull brown to nearly black. There is a broken light line down the middle of the back and a faint light line on each side. They appear greasy in texture. The moths are a dull, mottled brown, darker than the variegated cutworm moths.

Other species are much the same size in larval and adult forms. The moths are generally dull brown or blackish.

Development. The cutworms that attack grapes spend the winter in the vineyards as partially grown larvae in the soil. When the temperature becomes warm enough in the spring, the larvae emerge at night to feed on many kinds of succulent plant material, including the buds and young shoots of the grape vine.

In the late spring the larvae become full grown and enter the soil to pupate. The moths emerge and mate, and the females soon begin to lay eggs.

The variegated cutworm moth lays its eggs in batches of 60 or more on leaves and stems, on twigs and branches of trees, or on fences and buildings. The eggs are small, round, and flattened, and they are laid in rows. Many other species of cutworms prefer to lay their eggs on the stems of grasses near the ground.

Grass and other weeds in the vineyard furnish food for cutworm larvae, as well as favored locations for the moths to lay their eggs. Vineyards having a heavy crop of grasses in the fall are more apt to have cutworms the following spring than vineyards that are clean cultivated. Nearby grasslands, pastures, and alfalfa fields serve as reservoirs of cutworms.

On hatching, the young feed on low-growing vegetation. By the time the first brood has hatched, the grapevines have so much foliage and are growing so vigorously that the cutworms generally do but little damage the rest of the season.

Injury. Cutworm damage to vines occurs from the time the buds begin to swell until the shoots are several inches long. In the daytime these larvae hide themselves in the loose bark or soil at the base of the vines and are very hard to find. At night they climb the vines and feed into the buds and succulent shoots from one side. Shoots are often eaten only partway through so that they are weakened and fall over.

This habit of partially cutting off the succulent stems of many different kinds of plants gives the cutworms their name. If there is not enough food near the ground, some climb vines and trees to feed and thus become known as climbing cutworms.

Control. Cultural practices have not been generally successful in controlling cutworms. Plowing under the grass in the fall is of some value because it exposes some of the insects to the weather and to predators. Poison baits have given variable results when spread near the trunk of the vines late in the day. Sticky bands have been used successfully, but the application of the banding material is a slow, messy, distasteful job, which must be done very carefully. Sometimes the bands become covered by drift of sand, dust, and other debris and thus lose their effectiveness.

In commercial vineyards, DDT dusts and sprays have almost completely replaced sticky bands and poison baits.

Applications should be made just before the buds start to swell in the spring, or as soon as feeding damage is observed. The use of DDT for control of grape bud beetles or click beetles will also control cutworms. A 5 per cent DDT dust may be applied by hand at the rate of 30 to 40 pounds per acre and directed to the trunks, arms, and stakes touching the vines. Rains may make necessary a second application of dust.

A spray of DDT may be applied with little effort where vine planting and terrain permit the passage of power sprayers. Two spray men may ride the spray rig and spray the vines on either side while moving through the vineyard. The spray should be directed on top of the arms and canes, with less attention to the trunks of the vines. Large, wide-crowned vines are more difficult to spray rapidly by this method. The recommended application is 4 pounds of 50 per cent DDT wettable powder and ½ gallon of dormant oil emulsion per 100 gallons of water, applied at the rate of about 100 gallons per acre.

Cutworms may also be controlled by a 2.4 per cent DDT-oil vapor-spray used at the rate of 5 to 6 gallons per acre. Both of these sprays will persist through rainy weather so that, normally, only one application is necessary for cutworms. To check the effectiveness of DDT, one should visit the vineyard early in the morning of the day after the application is made. Soon after sunrise birds usually eat most of the cutworms killed by DDT.

In the home garden a DDT spray may also be used. Another method is to fasten a collar of cotton batting or wool on the trunk of the vine several inches above the ground. A strip of material about 5 inches wide should be used. The lower edge is tied with string, and the upper part of the band is then turned down over the lower edge. No avenue should be left over which the cutworms may reach the developing buds and young shoots of the vine.

GRAPE BUD BEETLE

The grape bud beetle, *Glyptoscelis squamulata* Crotch, was first found on grapes in California in 1923 in the Coachella Valley, and in the next ten years it spread to practically all of the vineyards in that valley. It soon became the major pest of grapes in that area and occasionally destroyed more than half of the crop. Later this pest appeared in the Imperial Valley. In 1936 it was found in parts of Fresno County and about 1950 was found in one vineyard

Left, grape bud beetle (about 6 times natural size). Right, egg mass of grape bud beetle; 42 eggs laid by one female.

near Lodi. Thus far, it has not appeared on grapes in other grape-growing areas, but this is always a possibility. This insect is a native of the western United States. Normally it feeds on various weeds, especially the mallow (*Sphaeralcea*) in the Coachella Valley. In the Sacramento Valley it is commonly found on poplar and willow.

Grape bud beetles may be numerous in the vineyard and still remain invisible to the grower because, like cutworms, they conduct their feeding operations at night and conceal themselves during the day. From observations of the damage alone, it is difficult to decide which pest is responsible. If, however, a grower wishes to satisfy his curiosity, he should examine the vineyard with a flashlight after dark on a warm spring evening.

Appearance. The beetles are light-gray, hard-shelled insects about ¼ inch long. Only a few beetles feed on the buds at one time, the great majority remaining hidden under the bark of the vine. Consequently, if very few beetles are seen, it should not be concluded that the infestation is so slight as to be of no economic importance.

Development. The female lays her eggs in the spring and conceals them in the deepest cracks in the grape bark. She lays them in compact masses of 20 to 30 eggs each. In a few days the eggs hatch and the young larvae crawl or fall to the ground, immediately burrowing into the soil. Here they seek the roots of the vine and feed on them, without, however, producing noticeable loss of vitality in the vine. The larvae may go to a depth of 2 or 3 feet in quest of roots. They remain in the soil all summer and all winter. In the early spring the larva constructs a smooth cell in the soil and in it transforms to the pupal stage from which the adult beetle later emerges.

Injury. Like the cutworm, in the spring the grape bud beetles feed on the opening buds during the night. With the approach of day they crawl down and hide in the rubble on the ground or under loose bark on the trunk and arms of the vine.

They feed on the swollen or opening buds, usually starting at the tip of the bud and gouging out the heart, leaving the bud scales nearly intact. Close inspection is therefore necessary to discover the hollow, dead buds. After the new shoots are 1 or 2 inches long, the injured buds are conspicuous by their lack of growth. Occasionally, one or both side-growing points of the bud are not injured and may produce canes that are apt to be unfruitful.

Control. Control of the grape bud beetle is achieved with DDT. This may be applied either as a dust or a spray. If the dust is used, a 5 per cent DDT dust may be applied with a hand duster at the rate of 30 to 40 pounds per acre. The dust should be applied to the stakes as well as to the trunk and arms of the vine. The purpose is to cover with DDT all paths by which the beetles will walk from their hiding places to the opening buds.

Although the beetles have wings and can fly, they rarely choose to do so. Walking through the DDT deposit, they pick up enough on their feet to kill them. After a heavy rain it may be necessary to dust again.

DDT may also be applied as a spray by mixing 4 pounds of 50 per cent wettable powder in 100 gallons of water and applying about 100 gallons of this mixture per acre, at low pressure. The addition of ½ gallon of oil emulsion per 100 gallons will enable the deposit to persist through several rains.

Another successful method of control, which has the advantage of rapid application, consists of vapor-spraying with a solution of DDT in petroleum oil, using no water. The solution should contain 2.4 per cent DDT and should be applied at

5 to 6 gallons per acre, as soon as the first damage appears.

CLICK BEETLE

Click beetles are better known throughout California as wireworms because the immature or larval stage is a wireworm. Truck crop growers usually refer to click beetles as "adult wireworms." Grape growers, however, are not concerned with the wireworm stage because it rarely, if ever, is injurious to grape roots. Wireworms are common in vineyard soils but apparently feed mostly on roots of weeds and cover crops. The adult, or click beetle, on the other hand, is often a serious pest in vineyards.

Click beetles are easily recognized by a characteristic action and sound. If one of these long, slender, hard-shelled beetles is held between the thumb and finger, it will arch its body backwards, then straighten out with an audible snap.

Of the hundreds of species of wireworms in California, only one, the Pacific Coast wireworm, *Limonius canus* Le Conte, is regularly injurious to grape buds. Other species are frequently found in vineyards, but they emerge too late in the spring to damage the opening buds. In spite of its name, it confines its attack to the interior valleys and is probably absent in the actual coastal belt.

Appearance. The female adult may attain a length of ½ inch, the male a length of about ⅜ inch. The females have reddish-brown wing covers, and the head and thorax are dull brown. The male lacks the distinct reddish tinge in the wing covers and appears dull grayish brown.

Development. The adults of the Pacific Coast wireworm hibernate during the winter under rubble on the ground and emerge to feed on warm days in March. They feed on pollen and are often found in various flowers.

The click beetle lays its eggs in the soil. In two or three weeks they hatch, giving rise to minute, young wireworms. The larvae, or wireworms, are well named since the long, slender, hard, polished body suggests a piece of wire. When the wireworm is fully grown, it constructs a cell in the soil and therein transforms to the adult, or click beetle.

Injury. The damage done to buds of the grapevine in the early spring by the click beetle is identical with that of the cutworm and bud beetle. Unlike these two latter pests, however, click beetles may be seen feeding at the apex of the buds in full daylight. Since they have wings and fly readily, they reach the spurs by flying instead of walking as do the cutworms and grape bud beetles. Their flight activity is particularly noticeable in late afternoon on warm days.

Control. Control of this pest is achieved with DDT dust, spray, or vapor-spray as described for the control of the grape bud beetle on page 46. However, since the click beetle flies to the

Click beetle destroying swollen bud on a spur.

Little bear beetle feeding on a grape shoot.

spurs, it is not necessary to spray stakes and trellises. The DDT should be applied whenever damage becomes apparent. Click beetles alone seldom occur in sufficient numbers to warrant chemical control measures, but when their damage is added to that of cutworms or bud beetles, the total bud injury may result in severe crop losses.

LITTLE BEAR BEETLE

Although the little bear beetle, *Pocalta ursina* (Horn), is widely distributed throughout California, it has been a pest of grapes only in the southern San Joaquin Valley where climatic and other factors are especially favorable for its development.

Appearance. The little bear is one of the largest insects that attack grapes. The adult beetles have broad, thick, hard bodies and vary from ½ to nearly 1 inch in length. In most of them, the wing covers are dark reddish-brown, but in a few the wing covers may be black or light brown. The head and thorax are black and in certain lights will give a suggestion of purple sheen.

Development. The females lay their eggs in the soil, and the white, six-legged grubs spend their entire time in the soil, probably feeding on the roots of grasses.

Injury. In the southern San Joaquin Valley the adults occasionally attack the young, tender shoots in late March and April. No case of injury by the soil-living grubs to the roots of grapevines has been discovered.

Control. This pest can be controlled with a 1 per cent parathion dust, applied at about 30 pounds per acre. Application should be delayed until the damage reaches economic proportions.

FLEA BEETLE

The flea beetle is so named because it can jump like a flea. Several different species are known to attack grapes in different parts of the country, but in California the steel-blue grapevine flea beetle, *Altica torquata* Le Conte, is the only species of importance.

Appearance. The adult beetles are shiny metallic blue or purple, about 3/16 inch long.

Development. The adults overwinter in surface debris and become active in the spring when the grape buds are swelling and opening. After feeding for a few days they lay small, light-brown eggs in cracks in the bark or at the base of the buds. The eggs hatch at the time the new leaves are expanding. The newly emerged larva feeds on the upper surface of the expanding leaves for three to four weeks, eating out irregular holes in the leaves. When fully grown the larvae are about ⅓ inch long. They are yellowish-brown with black markings. When mature, the larva drops to the ground and penetrates to a depth of about 1 inch to form a cell in the soil in which to transform to the adult beetle. A week or two later the adult beetles emerge from the soil. During the rest of the summer they feed sparingly.

There is only one generation each year. The adults show no tendency to mate or lay eggs during the summer and fall before going into hibernation.

Injury. Upon emerging from hibernation in the spring, the adults attack the swelling and opening grape buds and may completely destroy them. This pest, if unusually abundant, may destroy all the buds in a vineyard, but usually only part of the vineyard is attacked.

Control. DDT dust or spray, applied as soon as the adults appear on the vines, will control this pest. A 5 per cent DDT dust should be used, applied at the rate of 30 to 40 pounds per acre. If the vines are sprayed, the recommended mixture is 4 pounds of DDT wettable powder in 100 gallons of water, applied at about 100 gallons per acre at low pressure to avoid blowing off the buds and young shoots.

The Roots

GRAPE PHYLLOXERA

Although the grape phylloxera, *Dactylosphaera vitifoliae* Shimer, is native to the United States and has lived here many thousands of years on native wild grapes, it did not occur west of the Rocky Mountains until discovered in California in 1852.

From its inception, phylloxera spread rapidly. It is now quite generally distributed throughout the state, although southern California has only localized infestations and a few counties in the San Joaquin Valley are believed to have none.

California is especially fortunate in that the winged migratory forms do not succeed here as they do in the eastern states and in Europe. Spread of the pest is therefore limited to the distance the wingless crawlers can cover, and they can travel only a few feet. During late summer and fall occasional winged phylloxera appear in coastal areas. They emerge from the soil and fly about, but, unlike the eastern forms, they are unable to establish new colonies.

Appearance. These minute, oval or pear-shaped insects are best recognized by the damage they do, since their entire life is spent on the roots of the vine. Microscopic in size, the adult phylloxera is yellowish-green or yellowish-brown (see illustration, page 4).

Development. The mother remains practically stationary on the root of the vine and her eggs pile up around her. As the young hatch, many settle on the root close to the mother and begin feeding. Others show wandering tendencies. They crawl upward through cracks in the soil, travel a short distance on the surface, then enter cracks, crawl down the roots of another vine, and establish new colonies.

There are usually five generations each season, but in exceptional cases eight have been counted.

Injury. The combined feeding of the mother and young on the root of the vine causes gall formation. On new rootlets the galls are hook-shaped, on older roots they are half-spherical swellings. After a month or two the galls begin to decay, and the phylloxera then move to another place on the root and produce new galls. It is believed that the decaying galls and a poisonous saliva injected into the vine by the phylloxera are responsible for the stunting and decline of the vine. Root killing—especially the destruction of fine feeder roots—is of course partly responsible for loss of vigor.

Soil type plays an important role in phylloxera infestations. In order to prosper, the phylloxera requires a soil that will contract and crack when drying. Such a soil shrinks slightly away from the roots, thereby providing open passageways so the phylloxera may crawl along the roots to infest the whole root system. Also, cracks in the soil are the only means by which these aphids can leave an infested vine and reach the roots of an uninfested one.

In the San Joaquin Valley the soils of heavier texture of the Madera and San Joaquin series are favorable to general phylloxera infestation. So are the adobe soils of the Porterville series. The sandy loams of the Hanford and Foster series are less favorable, while the Madera and Oakley sands and the Fresno sand and Fresno sandy loams are practically immune to phylloxera infestation. In gen-

eral, soils so sandy that they will not crack when dried after a thorough wetting will probably be immune.

Control. Control of phylloxera is largely a matter of prevention. The roots of American varieties of grapes have varying degrees of resistance to phylloxera. Numerous hybrids of American varieties have been produced that possess a high degree of resistance. These rootstocks should be used in situations where phylloxera presents a real threat.

Rupestris St. George is the standard phylloxera-resistant stock for wine-grape varieties on the nonirrigated soils in the coastal valleys of California. Under these conditions it is recommended and used almost exclusively.

Solonis × Othello 1613 is very resistant to phylloxera. It is used in the fertile, irrigated, sandy-loam soils in the San Joaquin Valley where nematodes are also a problem as it is quite resistant to root-knot nematodes as well. It is not known to be incompatible with any variety except perhaps Ribier. In nonirrigated soils and in very poor sandy soils the grafted vines are likely to be weak and unproductive.

Growers should guard against the accidental introduction of phylloxera into their vineyards. This pest may be spread by grape rootings and bench grafts that were grown in infested soil; by irrigation or drainage water flowing out of an infested area; by cuttings that have become contaminated with infested soil; by old vines that have been removed from infested vineyards; by tillage tools, especially disks and plows that tend to collect masses of soil; and by tractors and trucks, especially when the soil is muddy.

Nursery stock can be completely freed from phylloxera and made safe for planting in uninfested soil by first washing all soil from vines and roots and then treating by one of the following methods: 1) fumigation with methyl bromide gas in an airtight chamber, using 2 pounds of methyl bromide per 1,000 cubic feet of space, with the temperature above 65° F and air circulation provided by a fan or blower; or 2) completely submerging the vines for not less than 5 minutes in a mixture of 1½ gallons of medium summer oil of viscosity 72–80 and unsulfonated residue test of 90 or above, plus 1 pint of 40 per cent nicotine sulfate and 1 pint of sulfated alcohol liquid spreader in 100 gallons of water. The solution should be renewed after dipping no more than 5 lots of vines, and at least once every 24 hours. After treatment, the vines should be packed or heeled-in in clean sand, shavings, moss, or other material that will prevent drying and reinfestation.

ROOT-KNOT NEMATODE

Nematodes are spread chiefly by man accidentally transporting the pest. They are readily carried by water for considerable distances. They are also spread in the vineyard by cultivating tools. The young worms may remain in the root where they hatched and work their way along through the root tissue, but they may also move actively through the soil to reach and enter other roots, though their own movement is extremely slow. (It is estimated that a nematode might travel 1½ feet in 24 hours if it kept to a straight course.)

Soil type, therefore, plays an important part in the severity of nematode infestations. Porous, sandy, or loam soils especially favor the increase and spread of this pest, whereas infestations in heavy soils are less serious.

Under favorable soil, moisture, and temperature conditions, the root-knot nematode, *Meloidogyne incognita* var. *acrita*, causes a decided weakening of growth and a decrease in production.

Appearance. In its young stages this pest is microscopic and worm-shaped. As the young worms grow and

mature, the males remain wormlike, but the females round up to a pear-shape.

Development. The eggs are laid within the root tissue or knot, a single female laying 500 or more eggs. Development of the root-knot nematode has no seasonable limits but progresses slowly or rapidly depending on temperature. The most rapid development occurs at about 80° F. At this temperature the eggs hatch in about 8 days and the young worms develop into egg-laying females in the next 16 to 18 days. Thus a generation may be completed within about 25 days and many generations are possible each year. At lower temperatures the development is slower, as at about 58° F a complete generation may require 100 days or more.

Injury. Abnormal growth takes place when the roots are infested, causing characteristic swellings on the roots when the young worms are present in large numbers. Such swellings usually cause enlargement of the whole root, whereas the swelling caused by phylloxera galls occurs mostly on one side of the root, or consists of hook-shaped galls at the tips of small rootlets.

Leguminous plants such as clover and vetch which may be uprooted in the vineyard will have small root galls, caused by beneficial nitrogen-fixing bacteria. Such galls are only loosely attached to the roots and are easily rubbed off, whereas nematode galls cannot be rubbed off. Nematodes frequently give rise to a series of knots on one root, somewhat resembling a string of beads.

Control. Since only a few localities with heavily infested, sandy soil present a real problem, control of the root-knot nematode is usually not necessary. In most soils grapes are not adversely affected by nematodes. Sandy-loam soils that are only lightly to moderately infested seldom require resistant vines if precautions are taken to reduce the nematode population as much as possible by clean fallowing for one or two seasons, or by growing resistant crops before planting the vineyard.

In heavily infested sandy soil the use of resistant rootstocks is the most effective means of control. The Solonis × Othello 1613 stock is suggested for fertile, irrigated sandy loam soils with all varieties except Ribier. Salt Creek is suggested for coarse sandy soils that may be low in fertility and for Ribier wherever nematode-resistant stock is required. Fruit produced by vines on nematode-resistant stocks is usually somewhat inferior in quality to that produced by own-rooted vines in noninfested soils. Growers are cautioned therefore to use grafted vines only when there is good reason to believe that they are required. Usually the areas requiring nematode-resistant vines are small in extent and may not include the entire vineyard.

All American varieties of grapes and hybrids are believed to be susceptible to nematode attack. The grape species *Vitis doaniana*, *V. champini*, *V. longii*, and *V. cinerea* show resistance to nematode attack. Salt Creek (*V. doaniana*), Dog Ridge (*V. champini*), and the two *V. longii* hybrids, Solonis × Othello 1613 and Solonis × *V. riparia* 1616, have shown good resistance to nematodes.

ROOT-LESION NEMATODE

The root-lesion nematode, *Pratylenchus vulnus* Allen and Jensen, may also cause stunting, poor growth of vines, and lowered yields. Both young and adult worms can be found in the soil around infested plants. In contrast to the root-knot nematode, it does not cause the formation of galls on the roots, nor do the females become swollen and sac-like. Males and females are elongate worms and are able to penetrate into roots in both the larval and adult stages.

These nematodes penetrate into small roots, and if the infestation is severe the roots are killed. Severely injured plants

usually have a greatly reduced root system; lighter infestations may induce the production of numerous lateral rootlets. Information is not available concerning the susceptibility of grape rootstocks to this nematode. However, the rootstocks resistant to root-knot nematode do not appear to be resistant to root-lesion nematode.

WESTERN GRAPE ROOTWORM

In recent years the western grape rootworm, *Adoxus obscurus* (Linn.), has been of minor importance in California, but about 40 years ago it was a serious pest. It is still present in most vineyards but has become so scarce that it does only negligible damage. In the grub, or larval, stage it feeds on the roots of the vine. The insect's life history suggests that its gradual disappearance may be due to the use of the disk rather than the moldboard plow for cultivation.

Appearance. Like the bud beetle, this little brown or black beetle, about 1/5 inch long, is seldom seen because it is nocturnal. It is recognizable chiefly by the obvious damage the adult does to the leaves of the vine.

Development. The adult beetles emerge from the soil in May and feed for about two weeks on the leaves in the lower part of the vine. The female selects a narrow crevice in the bark and wedges her eggs into this crack in groups of 20 to 30. The pale yellow eggs hatch in about two weeks and the young larvae make their way to the soil, burrow in, and seek out the roots of the vine. Here they remain from June to April of the next year.

By fall the larvae are full grown and are recognizable as white grubs about 1/3 inch long with a brown head and three pairs of short legs near the head. The body is curved into a C-shape. As winter approaches they burrow down in the soil to a depth of 2 feet or more, where they spend the winter. In the spring they burrow upward to within a few inches of the surface, and here they construct a smooth-walled oval cell in which to pupate. Disking at this time may crush many that are in the pupal stage; the larval stage is much tougher and not easily crushed.

Injury. Slitlike holes in the leaves indicate the presence of the western grape rootworm. While feeding, the adult beetles stand on the upper surface of the leaf and cut slits about 1/20 inch wide and of various lengths, often 1/4 to 1/2 inch long. In severe infestations the leaves are so completely eaten that they

Left, adults of the western grape rootworm and typical feeding slits cut in the leaf. Right, damage by western grape rootworm and typical feeding slits cut in the berries.

appear lacelike, and the vine may be completely defoliated. In such severe cases the beetles also feed on the green bark of canes and cut shallow grooves in the berries. Berries that have been thus nipped become misshapen and cracked.

During the larval stage in the soil this pest may eat small rootlets completely, but if roots are the size of a lead pencil or larger the rootworm gouges holes through the bark and outer wood. Often the larvae feed along the length of a root, leaving behind them a channel filled with frass and chewed wood. If the feeding channel happens to spiral around a root, it will be girdled and die.

Control. This pest can be controlled by spraying or dusting with DDT to apply 2 pounds of actual DDT per acre. The application should be made as soon as the holes become numerous in the leaves, and that should be just before or just after blooming. DDT applied for grape leafhopper control may also reduce the numbers of the grape rootworm.

Lead arsenate or calcium arsenate, 4 to 6 pounds in 100 gallons of water, sprayed on the vines will give good control, but these chemicals should not be applied much after bloom or a poison residue will be present at harvest time.

GROUND MEALYBUG

The ground mealybug, *Rhizoecus falcifer* Künkell, is a minor pest of grapes. It has not been found in commercial vineyards and is only occasionally injurious to backyard vines in the coastal areas. It feeds on many other plants as well, including grasses, broad-leafed annuals, cacti, citrus, deciduous fruit trees, and ornamental shrubs.

Adult ground mealybug in the soil.

This pest lives entirely in the soil, feeding on the roots of the vine. Superficially, it does not look like a mealybug because of its smaller size, long slender body, and absence of the wax rods and filaments that characterize other mealybugs. Its body is covered uniformly with white, waxy powder.

Chemical control of this species has never been necessary in commercial vineyards, and since it occurs rarely on backyard vines no chemical control method have been devised.

The Raisins

INDIAN-MEAL MOTH

The Indian-meal moth, *Plodia interpunctella* (Hbn.), is a serious pest in stored raisins, as well as many other types of dried fruits and nuts. Although usually not as numerous as the raisin moth, this pest can be very destructive because, unlike the raisin moth, it continues to lay its eggs in cracks and crevices in sweatboxes and other containers. Upon hatching, the larvae may crawl through the cracks to the inside of the container.

This pest readily enters houses and lays its eggs on exposed raisins in open packages on the pantry self. In such instances it is easier to discard small infested lots than to attempt cleaning and fumigation.

Appearance. The Indian-meal moth is about 3/8 inch long. Its wingspread measures about 5/8 inch. When at rest the wings are folded around its body. The outer two thirds of the front wings are a dark coppery brown; the other third, near the body, is cream-colored. The hind wings are grayish.

Development. The female moth lays approximately 300 gray-white eggs, which adhere loosely to the surface of the fruit, hatching in about 5 days. The worm, or larval, stage is completed in 30 to 40 days in the summer. The full-grown larva spins a silken cocoon in which to pupate. The pupal stage lasts 5 to 10 days in the summer. There are usually five generations each year. This pest passes the winter in the worm stage, either resting in cocoons or lying dormant in feeding tunnels in the dried fruit. Hibernating worms are able to survive the coldest winter temperatures out of doors in California. Transformation of overwintered worms begins in March and continues to the end of May.

Injury. Losses caused by the Indian-meal moth are due less to a reduction in quantity than to the lowering of quality, expense of extra handling and cleaning, and possible seizure and condemnation under the Federal Food and Drug Act, as well as possible rejection by the purchaser.

Infested raisins not only contain living

Left, adult Indian-meal moth (about 5 times natural size). (Photograph by F. M. Summers.)
Right, larva of the same moth (about 6 times natural size).

worms but are also increasingly polluted by excrement, cast skins, webbing, dead worms, and silken cocoons. Their filthy appearance may cause a curtailment of the market by public discrimination against raisins.

Control. Control of this pest and other storage pests of raisins is accomplished primarily in the packing house. Formerly, little was done to control insects in stored raisins. The practice of fumigating stored raisins with methyl bromide is increasing. As raisins are removed from storage, they undergo several processing steps before they are packaged and made ready for sale. Each step in the processing—sorting, cleaning, stemming, etc.—progressively reduces any infestation that may have been present. Raisins that have been fed on enough to make them lighter in weight are also automatically removed during processing.

At some step in the processing a fumigation treatment is applied. The raisins may be treated before packaging with a fumigant such as methyl formate. More commonly a liquid fumigant such as ethyl formate is added to the raisins as they are packaged. Cartons of 30 pounds, usually packaged for the bakery trade, are fumigated in most plants. Smaller packages are also fumigated. The liquid fumigant may be added to cartons containing smaller packages or placed in each package individually. Machine-sealed packages vary in their ability to exclude insects.

If any sizable amount of raisins is to be kept in home storage, they may be fumigated in any gastight container such as a clean garbage can, the lid of which can be sealed with butcher's tape. Or 5-gallon cans or glass jars that can be made gastight can be used. A commercial mixture of ethylene dichloride and carbon tetrachloride may be used for this purpose. This liquid should be used at the rate of two teaspoonfuls per cubic foot of space to be fumigated. The fumigant should be placed in a shallow pan resting on top of the raisins in the fumigation chamber. ***The operation should be done out of doors away from fire, and care should be taken to avoid breathing the fumes.*** The temperature should be 70° F or higher, and the container should be kept tightly sealed for at least 24 hours.

RAISIN MOTH

Although the raisin moth, *Ephestia figulilella* Gregson, is known to feed on ripening grapes on the vine, it is chiefly a pest of raisins in storage, especially in farm storage before the raisins are delivered to the packing houses.

Appearance. The raisin moth is about the same size and shape as the Indian-meal moth and folds its wings around its body in the same manner when at rest. It can, however, be easily distinguished by the drab gray of the forewings, and the markings on the wings are obscure. The hind wings are whitish. There is much less difference in intensity

Adult raisin moth (about 6 times natural size).

Larva of raisin moth (about 5 times natural size).

of color between the fore and hind wings of the raisin moth than there is between the fore and hind wings of the Indian-meal moth.

Development. The adult moth generally lays her eggs on raisins drying on the trays, but she may also lay them on raisins in storage. When the worm is full grown, it leaves the storage in search of a suitable place to transform to the moth stage. Any tight, dry, dark place is suitable, such as under boards, paper, or stones, or in the soil. When it has found a satisfactory place, the worm spins a silken cocoon. The full-grown worms pass the winter in their cocoons; they pupate and transform to the moth stage during April, May, and June, the great majority of the moths emerging in June. On warm evenings they begin to fly and lay eggs about half an hour after sunset, and they continue to fly for three or four hours. The moths live for about 15 days, and each female lays about 350 eggs. In summer a generation is completed in 45 days. There are three overlapping generations each year and in some years a small fourth generation.

The new spring moths do not lay their eggs in raisin storages because the raisins have by this time become unsuitable to them. Instead, they fly about in search of newly drying fruit, and at this season waste mulberry fruit, drying on the ground, is among the first food available for the larvae. By June first-crop figs on the ground are infested, and soon afterwards fallen apricots, nectarines, peaches, prunes, and peach-pit piles become available for egg laying. By August ripening grapes on the vine—especially those showing bunch rot or a few prematurely raisined berries—become attractive to the egg-laying moths. Later, they turn their attention to the raisins drying on the trays.

Injury. The raisin moth is destructive only in the larval stage. The young worms, hatched from eggs laid on raisins in storages, feed chiefly on the crests of the ridges of the raisin, but they may also bore into the flesh to the seeds. They do not consume a raisin but move about, leaving behind them a mass of excreta and webbing. During its development, one worm damages about 20 Thompson Seedless or nine Muscat raisins. The larvae of the raisin moth can also feed on ripening grapes on the vine.

Control. This pest can be controlled by sanitary cultural practices as well as by fumigation. As stated above, the raisin moth lays its eggs on the drying raisins at night. The high temperatures of the next day will kill the eggs unless they are shaded. When the time comes to roll raisins drying on paper trays, these should be prepared in biscuit rolls in the latter part of the afternoon, after the hot sun has killed the eggs that were laid the previous evening and before the moths have a chance to lay more eggs—in other words, before about 7:00 P.M. To protect the raisins from reinfestation, the rolls should be tight and should not contain too much fruit. Raisins in rolled trays should be boxed in the vineyard or immediately after the rolls are brought to the farmyard.

Late-maturing Muscat raisins dried on wooden trays, so that they can be stacked if rain threatens, are more exposed to attack by the raisin moth than raisins

dried on paper trays. The stacking of wooden trays protects the moth eggs from the killing rays of the sun. However, when wooden trays are stacked, the raisins can be protected from the egg-laying moth by a cover of shade cloth thrown over the stack.

Raisin cleaners driven by an electric motor have been found effective for removing infestation from Zante and Thompson Seedless raisins. About 90 per cent of the eggs and worms can be screened out if the screen is properly operated. The most economical procedure is to run the raisins over the cleaner into sweatboxes from the paper trays without intervening storage or extra handling.

Although the length of time that boxed raisins are stored on the farm is influenced by market conditions, prompt delivery to buyers is desirable because infestation increases on the farm during periods of favorable temperature. The degree of later reinfestation of raisins in storage in packing houses by the raisin moth is negligible. Covering the boxes with shade cloth keeps out much of the raisin moth infestation that would otherwise occur during storage on the farm.

Drying mulberry fruit is the first available food for the worms in early summer. If infested mulberry fruit under the tree is raked out into the sun and spread thinly, the heat will kill the worms and eggs. This practice and the use of a non-fruiting strain of mulberry for shade will reduce the local intensity of raisin moths.

DRIED-FRUIT BEETLE

The dried-fruit beetle, *Carpophilus hemipterus* (Linn.), is widely distributed throughout the world. Apparently any material that can be fermented may serve as food. Dried-fruit beetles are frequently found on figs—on trees or on the ground—in mushy citrus fruits, rotting apples, broken watermelons, etc. Thus, the chances are rather high that raisins will become infested whenever the conditions of storage are favorable.

Raisins that have become moist enough for fermentation to start are especially susceptible. There is little infestation in the field if raisins are made from sound grapes. If the beetles do occur on grapes in the field, they are most likely to be found during the latter part of the fall and winter; it is during this period that they are most abundant in raisins.

Appearance. The adult beetles are dark brown with lighter brown or amber spots. They are about ⅛ inch long, oval in outline, and robust. The wing covers, which bear the lighter brown spots, are short, leaving the abdomen exposed at the tip. The antennae are knobbed at the tips. Legs and antennae are reddish or amber.

These beetles are strong fliers—marked beetles have been collected 2½ miles from the point of release after four days. Flight occurs only in daylight hours at temperatures above 65° F. The greatest flight activity takes place at temperatures between 80° and 100° F.

Dried-fruit beetle.

Development. Each female lays about 1,000 eggs which are scattered over the raisins. The eggs hatch in 1 to 5 days (about 2 on the average) and the translucent yellowish larvae start to feed.

The larvae soon become creamy white, brownish at both ends. They have a pair of pointed processes at the tip of the abdomen. When fully grown, they are sparsely hairy and about ¼ inch long. The slender larvae are active and move about quickly. The larval period varies with the temperature, lasting 11 days at 80° F.

Whenever possible the full-grown larvae enter the soil and make earthen cells in which to pupate. The pupae are a pale yellow until nearly mature. At 80° F the pupal period is about 8 days. Mating takes place soon after the adults emerge from the soil and eggs are laid from 1 to 8 days thereafter. Egg laying may start as early as 3 days after the adults have emerged from the pupal cell.

During warm weather there may be a generation every three weeks. Actually there are several overlapping broods each year, the number of generations depending on the temperature. The larvae entering the soil in the fall may not emerge as adults until spring because of the low temperature.

Adult saw-toothed grain beetle (about 9 times natural size). On the margins of the thorax are minute, sharp, sawlike teeth.

Injury. The larvae feed directly on the flesh of the raisins, and this feeding, together with the excreta and cast skins, makes such a mess as to materially reduce the quality of the dried fruit. No feeding or development takes place below 40° F.

Control. Control of this pest is accomplished primarily in the packing house. The control measures are the same as those used for control of the Indian-meal moth (page 55).

SAW-TOOTHED GRAIN BEETLE

The saw-toothed grain beetle, *Oryzaephilus surinamensis* (Linn.), is a cosmopolitan pest that feeds on practically all dried, stored food. It infests all cereals (such as rice, wheat, maize, and barley), pastes (such as macaroni), bread, flour, nuts, copra, starch, drugs, tobacco, dried meat, and dried fruit. Raisins are one of its favorite foods.

Appearance. The adult is a very active, slender, flattish, brown beetle, about $\frac{1}{10}$ inch long. It can be recognized by the sharp projections that stand out on each side of the thorax. These somewhat resemble saw teeth and are responsible for the pest's name.

Development. The adult female lays her eggs singly or in small clusters in crevices formed by tight folds in the skin of the raisins. A beetle may lay from one to six eggs a day and about 250 eggs in her lifetime. The eggs are white, shiny, and elongate-oval. Measuring less than $\frac{1}{20}$ inch in length, they are not visible to the unaided eye.

During warm weather the eggs hatch in about four days. The larva is pale yellow with a dark band on each segment, and its body is covered with numerous long hairs. The head is yellowish-brown. The larvae have six legs and crawl

actively about, not confining their feeding to a single raisin, but nibbling at random. Fully grown, they measure about $\frac{1}{10}$ inch in length. During warm weather they mature in about two weeks.

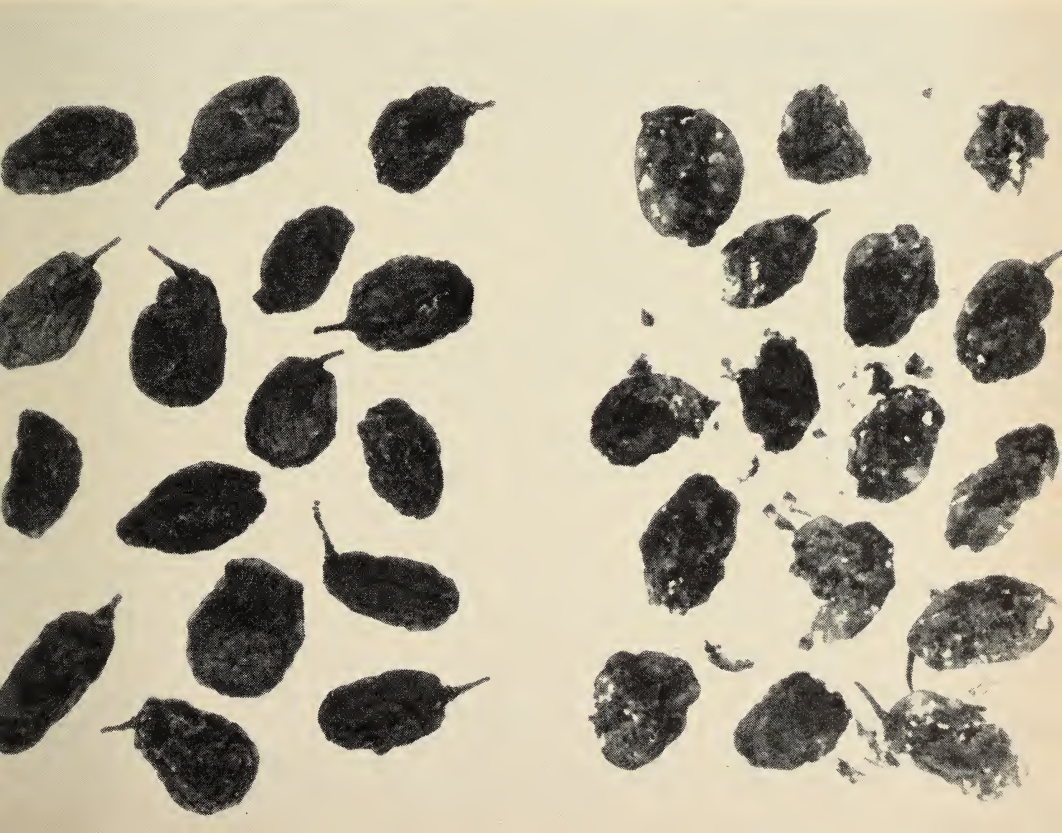
When ready to transform to the adult, the larva may construct a crude cocoon of tiny particles of trash fastened together with a gluelike material which it secretes from its mouth. The larva firmly attaches its rear end to some solid object and changes to a pupa. At the end of about 15 days, the adult beetle emerges.

During warm weather the time from egg laying to the emergence of a new adult is about 40 days. There are normally five to six generations each year. With the approach of cold weather the adults hibernate; but indoors in warm buildings they continue to breed and develop throughout the year. Thus, infestation may take place during the storage of raisins. Adult beetles in captivity have lived more than three years.

Injury. The saw-toothed grain beetle attacks all parts of the raisin, feeding as much in the deep folds as on the ridges. There is no webbing as is the case with Indian-meal moth or raisin moth damage. The excreta of the saw-toothed grain beetle are yellowish, and the pellets are smaller and more elongate than those of the moth larvae.

Control. Control measures are the same as those used for control of the Indian-meal moth (page 55).

Left, normal raisins; right, the same raisins after saw-toothed grain beetle infestation. (Courtesy of Dr. Oscar Bacon.)



In Wineries

LEAD CABLE BORER

The lead cable borer, *Scobicia declivis* (Le Conte), which derives its name from its habit of boring holes in the lead sheathing of telephone cables, also bores holes in wine casks.

Appearance. The adult is a black, cylindrical beetle about ¼ inch long, with a tan or reddish spot on each side of the body near the middle. Both males and females are strong fliers and fly a good deal during warm days.

Development. This pest breeds almost entirely in oak trees, preferring the California live oak and the black oak. Females do not lay eggs in healthy, living oaks or in dead wood that is invaded by various wood-rot fungi. Instead, they seek out healthy wood that has been cut, felled, or broken by the wind, preferably wood that has been severed from the tree for a period of two weeks to six months.

To lay her eggs the female bores through the bark of the oak to the wood, then turns and burrows through the wood parallel to the bark and at right angles to the grain. Eggs are inserted into natural wood pores which are crossed by the tunnel made by the adult. In about 20 days the eggs hatch into white, C-shaped grubs that bore through the wood. This stage lasts about nine months. The grubs then construct a hollow cell in the wood in which to pupate. At the end of about 15 days the adult emerges, remaining inside the pupal cell for about a month while it matures, hardens, and turns black. It then bores its way out and flies off in search of new oak wood.

The lead cable borer has only one generation each year. The adults occur from May to September, inclusive, but are most abundant during July and August. Most of the new adults emerge from the grub-infested wood from July 20 to 30 and live for about 30 days thereafter.

Injury. In wineries the adult stage of the lead cable borer is the destructive one; the white, grublike larvae are not found. These beetles are provided with organs of smell which enable the females to locate freshly cut oak. This odor must resemble alcohol because the beetles are attracted to wine casks and tanks, boring into the wood as though intending to lay eggs there. Brand-new oak barrels that have never held wine are attractive to the beetles and so are redwood tanks that have held wine; new, unused redwood, however, is not.

Some vintners believe that the beetles enter the winery at night and bore holes in the casks because they find wine leaking out in the morning where no hole was noticed the day before. This is not correct because a female beetle can bore only ½ inch of tunnel in 24 hours.

Control. Control of this pest in wineries should include sanitation in the immediate neighborhood. Since the beetles breed in oak wood that has been cut for two to six months, no such cordwood should be piled near the winery. If native oaks are growing nearby, any broken limbs on the ground should be burned by May of each year before any adults can emerge.

Some vintners fill their tanks with water and heat it nearly to boiling in the belief that this procedure kills beetles established in the wood. If this is done early in August, any adults that were boring in the staves at the time of treatment would be driven out by the heat,

but the tanks would again be susceptible to attack as soon as they had cooled. There are no eggs or grubs in the wood of the tanks to be killed by heat treatment. Heat treating at any other time than July and August would be futile, and it is of doubtful value during these two months.

An old method of protecting the casks from beetle attack is to paint the outside of the cask with a hot, saturated solution of alum in water. As soon as this coat is dry, the cask should be painted with linseed oil. Painting or spraying the outside of the casks with wettable DDT powder has been suggested by some vintners but has not been tested by the authors.

POMACE FLY

The name of pomace fly or vinegar fly is applied to various species of *Drosophila* but especially *D. melanogaster* Meig in northern California and *D. hydei* Sturdevant in southern California. The flies are attracted to fermenting fruit of all kinds and are familiar to all as the tiny yellowish flies that hover around garbage cans or wherever fermenting fruit is found. They become numerous in the late summer when large quantities of decaying fruit are available.

The pomace fly is believed to be a native of the tropics, and it has not acquired the ability to survive the winter outdoors in temperate climates. It does, however, survive the winter indoors wherever fruit is stored. Here it breeds slowly throughout the winter. A single rotting pear or apple will support about 300 flies through the winter.

The egg, laid on fermenting fruit, hatches in 24 hours, producing a slender white maggot which feeds on yeasts in the fermenting fruit. After four days (in the summer) the maggot forms a brown pupa from which the adult emerges after about four days. Thus, a generation is completed in nine days.

This fly is a pest in wineries because it is attracted to the fermenting tanks. The presence of dead pomace flies in the tanks may be considered unsanitary by the Food and Drug Administration. This agency would consider the wine adulterated if prepared in a fly-infested winery, even though filtering removed most of the visible evidence.

Control of the pomace fly is largely a matter of sanitation in and around the winery. Prompt disposal of waste materials is essential, and no pomace should be allowed to stand near the winery for more than five days.

GRAPE PESTS DESCRIBED IN THIS CIRCULAR

In order that the information in our publications may be more intelligible it is sometimes necessary to use trade names of products or equipment rather than complicated descriptive or chemical identifications. In so doing it is unavoidable in some cases that similar products which are on the market under other trade names may not be cited. No endorsement of named products is intended nor is criticism implied of similar products which are not mentioned.

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and this is what it looks like . . .

THE PHOTO above is taken from a circular on irrigated pastures in California. It shows a good lay-out of fences and gates for rotation grazing.

The drawing below is from a circular on selective weed killers and shows one reason why some weed killers are selective.

These pictures are typical of the practical, down-to-earth approach to farm problems used in many of the free publications put out by the University of California College of Agriculture.

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